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MAP OF THE ISLAND OF NEGROS, SHOWING THE PRESENT SUGAR DISTRICT.

Van der Sten

DEPARTMENT OF THE INTERIOR
BUREAU OF SCIENCE

THE SUGAR INDUSTRY IN THE ISLAND OF NEGROS

BY

HERBERT S. WALKER

*(From the Division of Chemistry, Government Sugar Laboratory at Iloilo,
Philippine Islands.)*



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CONTENTS.

	Page.
Introduction	9
General information regarding Negros.....	10
Geographical location	10
Size, shape, and area.....	10
Mountains	11
Rivers	11
Climate	11
The sugar belt.....	14
The east coast.....	15
Other sugar-producing districts of Negros.....	15
History of sugar production in Negros.....	16
Recent statistics	16
Varieties of cane grown in Negros.....	18
Cane diseases and insect enemies.....	19
Nationality of the planters.....	19
Native labor: Difficulties, past and present.....	20
The principal sugar-producing districts of Negros.....	22
Silay	22
Bago	27
Pontevedra-La Carlota	37
Binalbagan-Isabela	43
Ilog-Cabancalan	49
San Carlos	55
Bais	64
The soil of Negros compared with that of other sugar-producing countries....	68
Average composition of the soils of Negros.....	68
Hawaiian soils	70
Egyptian soils	70
Louisiana soils.....	71
Java soils	71
Demerara soils.....	71
Berbice soils	72
Mauritius soils.....	72
Comparison of Negros soils with those of other countries.....	72
Fertilization in Negros.....	73
The cane of Negros.....	76
Average composition of the purple or native sugar cane in Negros.....	76
Other varieties of cane grown in Negros.....	77
Cane in the Hawaiian Islands.....	79
Egyptian cane	80
Java cane	80
Louisiana cane	80
West Indian cane	81
Negros as compared with other countries in respect to the quality of cane	81
Desirability of introducing other varieties of cane.....	81

	Page.
The cultivation of sugar cane and the production of sugar as carried on	
at the present time in Negros.....	82
Preparation of the soil.....	82
Preparation of the seed.....	83
Planting	83
Cultural operations after planting.....	84
Cultivation of ratoon canes.....	85
Period of growth of the cane.....	86
Cost of cultivation	87
Cutting the cane.....	90
Transporting the cane to the mill.....	91
Cost of cutting the cane and transporting it to the mill.....	92
Manufacture of sugar from the cane.....	92
Extraction of the juice.....	92
Manufacture of sugar from the juice.....	99
Quality of the sugar produced in Negros.....	109
Cost of manufacture	112
Transportation and sale of the sugar.....	113
Estimate of average cost of same.....	114
Quantitative experiments to determine the weight of sugar produced	
from a given weight of cane.....	114
Mill Control No. 1, hacienda San Jose.....	115
Mill Control No. 2, hacienda San Jose.	118
Calculation of the average cost of producing sugar in Negros by the	
methods now employed	123
Cost for labor alone	123
Estimate of fixed charges for maintenance and depreciation of plant	
and interest on the capital invested.....	125
Total cost of production	126
Possibilities for improvement.....	126
In cultivation	126
In manufacture	127
Advantages of a change to modern methods of manufacture.....	132
The future of Negros.....	133
Summary	134
Appendix	139
An investigation to discover if diseases of the sugar cane exist in	
Negros	139
Index	143

ILLUSTRATIONS.

Map of the Island of Negros, showing the present sugar districts. The numbers refer to the soil analyses mentioned in the tables in the text. (Frontispiece.)

PLATE I.

- FIG. 1. Plowing a field just before planting the cane. Shows type of plow in most common use.
2. Steam plowing engine drawing two disc plows.

PLATE II.

- FIG. 1. Plowing between the rows of the young cane.
2. Boys clearing out the weeds from the young cane.

PLATE III.

- FIG. 1. Taking away dirt with hoes from around the roots of young ratoons. This field was cut and burned a week previously. In the background are bagasse sheds and camarin.
2. Cutting cane in the field.

PLATE IV.

- FIG. 1. Transporting cane on a man-power tramway.
2. Cutting seed or *puntas* from cane tops. The part not used for seed is fed to the animals.

PLATE V.

- FIG. 1. Women and children husking *puntas* which are to be used for seed.
2. Loading cane on wagons in the field. The cane is taken to the mill on a portable tramway.

PLATE VI.

- FIG. 1. Hauling cane from the field to the mill.
2. Sugar mill in action.

PLATE VII.

- FIG. 1. Carabao mill. At the extreme right note the bagasse coming out from the mill in long, unbroken strips.
2. Interior of the camarin showing the arrangements of the *cauas*, etc. In the rear is a pile of dried bagasse ready for use as fuel.

PLATE VIII.

- FIG. 1. Hacienda San Juan del Monte. Camarin and carabao carts. In the foreground may be seen the bagasse spread out on the plaza to dry.
2. Side view of a camarin. The two men in the center are carrying out a load of fresh bagasse to dry in the sun.

PLATE IX.

- FIG. 1. Sugar boiling in Negros. A night scene in the camarin of Hacienda Carmen Chica.
2. Loading sugar on lorchas in the Bago River for transportation to Iloilo.

PLATE X.

- FIG. 1. The Bago River and the sugar lorchas of the Hacienda Lumañgub. This is the farthest point up the river to which lorchas can go.
2. Temporary experimental laboratory.

P R E F A C E .

Several years ago the Director of the Bureau of Science realized the necessity of making an extended and thorough study of the sugar cane produced in the Philippine Islands, the nature of the soils as disclosed by chemical and physical examination, the area planted and the area available for sugar production. It was deemed necessary at the same time to study the existing methods of isolating the sugar and shipping it to the market in order to determine the benefits which might accrue from improved methods of grinding and evaporating. The necessity for this work was emphasized in the Annual Report of the Bureau of Science for the year 1908, and it was proposed to establish a staff which would employ at least three men for a sufficient length of time to complete the investigations; the undertaking including assistance from other Bureaus in the preparation of topographic maps. However, the Government did not believe itself in a position to inaugurate so extensive a piece of work at that time. Therefore, it was decided to do as much as possible with the laboratory force available to us, and in view of the fact that the Island of Negros produces the greatest amount of sugar for any given area in the Philippine Islands, it was deemed expedient to concentrate our efforts on that region. Mr. Herbert S. Walker, of the chemical laboratory, was detailed for this duty, he being stationed in Negros during the entire sugar campaign of 1908 and 1909 and, in addition, giving to the subject the attention necessary to complete the work as far as it was possible for one man so to do. He carried with him a portable chemical laboratory and hand mill and established his laboratory on the various haciendas in the island. The information which he was able to obtain was therefore gained at first hand. The soil analyses and such other chemical work as could not be performed on the spot were done at the central laboratory in Manila by Messrs. L. A. Salinger, R. R. Williams, and Wallace E. Pratt, the first two being of the division of chemistry and the latter of the division of mines of the Bureau of Science. The work which is published in the following monograph speaks for itself. Much remains to be done, even after considering the thorough and exhaustive report which has been made, especially in the direction of a study of fertilizers on the spot and in the introduction of other varieties of cane which would be available in case of accident to the present types

so extensively grown. However, in order to accomplish such a result the chemical laboratory must give way to the experimental station. The sugar production in other parts of the Philippine Islands will be taken up as opportunity permits.

The Bureau of Science wishes to express its thanks to all of the hacenderos of Negros who so courteously helped in this work, not only by supplying quarters for the laboratory, but by means of other assistance which often involved a considerable sacrifice of time on their part.

PAUL C. FREER.

THE SUGAR INDUSTRY IN THE ISLAND OF NEGROS.

By HERBERT S. WALKER.

(From the chemical laboratory, Bureau of Science, Iloilo sugar laboratory.)

INTRODUCTION.

The Philippine Islands in general and the Island of Negros in particular, with reference to the condition of their sugar industry, have probably been as thoroughly discussed and investigated as any sugar-producing country in the world, and with as little true knowledge of the facts. At least two large volumes bearing directly on this subject have already been published,¹ containing most highly variegated and conflicting testimony from more or less prejudiced parties. While undoubtedly many true and conservative statements are contained therein, they are so covered up by a mass of exaggerated conjectures and estimates made by over-eager friends and enemies of the Philippines as to be practically valueless as a source of information. During the past year, however, the Bureau of Internal Revenue has made a very thorough study of the sugar industry in these Islands from a statistical point of view, and secured reliable data as to the total area of lands planted and available for sugar culture and the amount of sugar actually produced in each municipality throughout the Islands, together with statements from individual planters in regard to the cost of production.

The object of the present investigation was to learn at first hand the conditions of agricultural practice in cane growing and sugar making actually prevailing here at the present time, and thus to prepare a foundation on which to base future efforts toward the advancement of the industry. It is obvious that only with an exact knowledge of facts concerning our own resources and conditions can we hope, by comparing them with those of other countries, to suggest means or to work out methods for their improvement. With this end

¹ Hearings before the Committee on Ways and Means, 1905. Hearings before the Committee on the Philippines of the United States Senate, 1906.

in view, the writer spent six months, or practically the entire milling season of 1908-9, on the Island of Negros, taking with him a portable laboratory for the analysis of canes, mill juices, bagasse, and sugar-house products, and, through the courtesy of the planters, was facilitated with conveniences for carrying on his work directly on the plantations in the more important sugar districts of the island, being at the same time afforded an opportunity of observing the methods commonly employed in the cultivation of cane and the production of sugar. Representative samples of soil were also secured from each locality, together with all possible data as to their productiveness in quantity and quality of cane and sugar yielded.

It was manifestly impossible in such an investigation to cover the whole Philippine Islands during one season. Choice must be restricted to a few typical localities in the largest sugar-producing section of the Islands. In point of total sugar produced, Negros has for many years led all other provinces; during the past forty years it has been more closely and intensely devoted to this branch of agriculture than any other section of the country; and, owing to the practical dependence of the majority of the inhabitants on the yearly sugar crop for a livelihood, the industry has been more highly developed here than in the majority of other sections. Out of a total of approximately 180,000 metric tons of sugar made in the Philippine Islands during the season of 1907-8, 73,498, or a little over 40 per cent, came from the Island of Negros alone. In 1893, the year of largest production for the Islands, Negros gave about 115,000 metric tons out of a total of 300,000. Here also may be found soils of every degree of fertility, from virgin forest lands and rich alluvial deposits to worn-out fields which have been cultivated for upwards of fifty years without fertilizing.

GENERAL INFORMATION REGARDING NEGROS.

GEOGRAPHICAL LOCATION.

Negros is situated at from $9^{\circ} 4'$ to $11^{\circ} 1'$ north latitude and from $122^{\circ} 24'$ to $123^{\circ} 34'$ east longitude. Three other important islands practically surround it: Panay on the north and west, at a distance of from 13 to 70 kilometers; Mindanao on the south, some 45 kilometers at the nearest point; and Cebu, distant 4 to 25 kilometers from the coast. Manila is some 500 kilometers northwest of Negros, while Iloilo, the principal shipping point for sugar, is distant about 45 kilometers from the west and 100 to 150 kilometers from the east coast.

SIZE, SHAPE, AND AREA.

Negros measures 200 kilometers in its greatest extension from north to south. In outline it is shaped roughly like a boot, the greatest

breadth in the lower part being in the neighborhood of 90 kilometers, and the upper half, containing most of the sugar lands, varying from 40 to 60 kilometers. The total area of the island is probably not exactly known; it has been stated by different authorities to be from 9,000 to 12,500 square kilometers.

MOUNTAINS.

By far the greater part of this area is occupied by mountainous or hilly forest lands, which are uncultivated, except for occasional small patches, "caingins," burned and planted for a season or so in corn by the semiwild mountain people. These mountains extend for the entire length of the island from north to south, but are much nearer to the east than to the west coast. The land itself is of volcanic origin, and the highest peak, Mount Canloan, is still partially active to the extent of sending forth occasional puffs of smoke.

RIVERS.

But one river, the Danao, is navigable for vessels of any considerable draft, and this lies in the mountainous, extreme northeastern part of the island, which is of little importance for sugar production. Three others—the Bago, the Binalbagan, and the Ilog—penetrate important sugar districts and permit entrance by flat-bottomed sugar "lorchas" for distances of from 5 to 10 kilometers. Countless other small streams break up the entire coast line of the island, but they are of very little importance except where they occasionally serve as sheltered landing places for small boats. It is owing to this lack of large rivers and harbors suitable for seagoing craft that no sugar is exported directly from Negros, but all is taken across in small sailing boats to Iloilo, the nearest large port. In fact the town of Iloilo owes its existence largely to the sugar industry of Negros.

CLIMATE.

The following data compiled by the Weather Bureau show the monthly maximum, minimum, and average temperature and rainfall at two meteorologic stations in Occidental Negros, one during the period 1891–1898 at La Carlota (La Granja Modelo), the other during 1903–1908 at Bacolod. In a country so broken by mountains as is Negros, the rainfall is especially liable to local variation, and it is no uncommon occurrence for one plantation to be without rain for several weeks, while a neighboring one may be enjoying daily showers. This is especially true in the northern and eastern parts of the island. No meteorologic station has been established as yet in Oriental Negros.

Maximum, minimum, and monthly mean of rainfall at La Carlota, Occidental Negros, deduced from the period 1889-1897.

Month.	Monthly maximum.		Monthly minimum.	
	Milli- meters.	Year.	Milli- meters.	Year.
January	179.9	1891	6.1	1896
February	144.5	1893	0.0	1897
March	113.0	1897	8.4	1889
April	292.9	1890	3.0	1889
May	177.0	1893	44.4	1889
June	415.0	1895	175.9	1891
July	607.0	1896	114.9	1894
August	588.0	1891	232.0	1894
September	623.4	1894	234.0	1896
October	887.8	1892	106.6	1895
November	368.4	1889	47.5	1896
December	262.9	1889	9.0	1896

Average of rainfall at La Carlota, Occidental Negros, deduced from the period 1889-1897.

Millimeters.		Millimeters.	
January	59.7	July	358.7
February	55.6	August	378.6
March	47.4	September	392.9
April	87.0	October	350.9
May	229.3	November	199.0
June	304.8	December	127.3

Maximum and minimum of temperature for each month of the year at La Carlota, Occidental Negros, deduced from the period 1891-1898.

Month.	Monthly maximum.		Monthly minimum.	
	°C.	Year.	°C.	Year.
January	31.0	1893	17.4	1893
February	34.9	1892	18.0	1893
March	35.5	1892	18.9	1893
April	36.4	1891	19.5	{ 1892 1894
May	35.6	1891	20.8	1891
June	34.1	1892	19.2	1893
July	34.8	1892	19.0	1895
August	33.4	1892	19.5	1895
September	33.5	1891	19.0	1893
October	34.9	1892	20.3	1891
November	33.6	1892	19.8	1895
December	34.7	1892	17.0	1892

Average of temperature for each month of the year at La Carlota, Occidental Negros, deduced from the period 1891-1898.

	°C.		°C.
January	25.6	July	26.3
February	26.3	August	26.0
March	26.7	September	26.2
April	27.6	October	26.7
May	27.6	November	26.3
June	27.0	December	26.0

Maximum and minimum of rainfall for each month of the year at Bacolod, Occidental Negros, deduced from the period 1903-1908.

Month.	Monthly maximum.		Monthly minimum.	
	Milli-meters.	Year.	Milli-meters.	Year.
January	255.7	1907	51.3	1903
February	178.3	1904	0.3	1906
March	36.9	1903	1.6	1905
April	113.4	1904	1.1	1905
May	206.2	1908	91.3	1903
June	399.2	1904	145.9	1905
July	415.1	1906	233.3	1907
August	433.8	1907	200.2	1903
September	417.1	1908	227.6	1905
October	362.5	1905	100.5	1908
November	189.8	1908	96.9	1907
December	429.2	1903	94.0	1906

Average of rainfall at Bacolod, Occidental Negros, deduced from the period 1903-1908.

	Millimeters.		Millimeters.
January	111.2	July	348.5
February	64.0	August	326.1
March	15.3	September	302.1
April	24.5	October	227.0
May	138.6	November	140.9
June	236.0	December	201.8

Maximum and minimum of temperature for each month of the year at Bacolod, Occidental Negros, deduced from the period 1903-1908.

Month.	Monthly maximum.		Monthly minimum.	
	°C.	Year.	°C.	Year.
January	35.4	1905	15.5	1905
February	35.9	1905	15.1	1905
March	37.8	1905	16.7	1905
April	38.2	1905	19.0	1904
May	37.8	1905	21.5	1908
June	34.4	1906	21.3	1907
July	33.0	1907	20.7	1906
August	32.6	1906	20.3	1907
September	33.9	1904	21.2	1903
October	34.3	1904	21.1	1904
November	33.9	1904	19.2	1906
December	32.6	1904	16.5	1904

Average of temperature for each month of the year at Bacolod, Occidental Negros, deduced from the period 1903-1908.

	°C.		°C.
January	26.0	July	26.6
February	26.0	August	26.0
March	26.9	September	26.7
April	27.8	October	26.8
May	28.4	November	26.4
June	27.4	December	26.3

During the milling season, from November to June, the northeast monsoon blows quite steadily, with few storms and comparatively little rain. Southwest winds prevail throughout the greater part of the rainy season, and, as in other parts of the Islands, a considerable amount of rough weather is experienced, but Negros is so well protected by adjacent islands that very little damage is ever occasioned by storms.

THE SUGAR BELT.

The greater proportion of the sugar of Negros is produced in the so-called sugar belt or coastal plain, which extends from the town of Victorias in the north to the Ilog River in the south, a distance along the west coast of approximately 130 kilometers. The width of this plain from mountains to sea is from 5 to 30 kilometers; however, all of this land is by no means suitable for growing cane. Much of it along the coast is covered by swamps, and the soil in the inland toward the mountains

is often rocky and nearly barren. The sugar belt from north to south may be divided into five important districts, each of which produces annually more than 5,000 metric tons of sugar. These districts comprise the following municipalities and their surrounding land:

1. Victorias, Saravia, Silay, Talisay; 2. Bago; 3. Pontevedra, La Carlota; 4. Binalbagan, Isabela; 5. Ilog, Cabancalan.

It is intended to take up each of these separately, giving whatever data possible regarding the character and composition of the soil, quantity and quality of sugar and cane produced, transportation facilities, and other available facts.

THE EAST COAST.

As has been stated previously, the principal mountain chain running through Negros from north to south lies much closer to the east than to the west coast. In addition to this, a secondary range of foothills extends on this side very nearly to the sea. No great coastal plain exists here, as on the west, but mountains or rugged hills descend abruptly to the strand, leaving only here and there scattered patches of land in the valleys of small streams, where sometimes a few hundred tons of sugar are produced. Exceptions to this rule are the districts of San Carlos in the north and Bais in the south, each located in a sheltered valley of considerable extent, and each producing annually about 5,000 metric tons of sugar. These two localities will be considered together with the five principal districts of the west coast.

OTHER SUGAR-PRODUCING DISTRICTS OF NEGROS.

The seven large districts just mentioned comprise the principal sugar centers of the island. Lying between these, along the west coast are several other municipalities and barrios, each of which yields from 1,000 to 3,000 metric tons of sugar per annum, but these are so isolated by lack of proper land transportation facilities that at the present time they must be considered as separate, comparatively unimportant sections, although with the advent of good roads and modern methods of sugar production many of them will undoubtedly be united to the nearest lying main districts. South of the Ilog River there is a large extent of forest land, mostly hilly, but containing several level plains where, it is stated, sugar cane may be as profitably grown as in any other portion of the island. However, this region is as yet undeveloped and it is impossible to give exact data as to its resources.

HISTORY OF SUGAR PRODUCTION IN NEGROS.

According to R. Echaúz,² the history of Negros as a sugar-producing country practically begins with the year 1849, in which year the island, by command of the Spanish governor-general, was placed under the jurisdiction of the religious order of the Recoletos. The rapid development of the industry which at once ensued and continued during the next forty years is attributed to the enthusiastic and untiring efforts of this corporation, ably assisted by the then British vice-consul, Nicholas Loney. Prior to 1849, some sugar was made in Negros, it is true, but only in very small quantities and by the crudest methods, cane being crushed in wooden mills, and the resulting juice boiled down to a sticky mass in small iron kettles over an open fire and sent to the market in small bundles wrapped in the whole leaf of the buri palm. The island was at that time practically unexplored and inhabited for the greater part by semibarbarous tribes of forest people. The following figures are given as illustrating the progress made from 1850 to 1893.

	1850.	1880.	1893.
Inhabitants of the island.....	30,000	200,000	320,606
Sugar, in piculs.....	3,000	618,120	1,800,000
Sugar, in metric tons.....	190	39,096	113,850
Wooden mills.....	7		
Mills run by steam.....		59	274
Mills run by water power.....		17	47
Mills of iron, run by animal power.....		495	500
Steam plows.....			3
Tramways (for transportation of cane).....			23

RECENT STATISTICS.

During the period from 1893 to 1895 the sugar industry of Negros reached a height of prosperity which it has never again attained. Since then it has suffered so greatly from war and animal diseases that for a time it was practically paralyzed, and, although a slight tendency toward recovery was experienced shortly after the period of greatest depression, the total production of the island has for the past few years remained very nearly stationary, at a figure approximating 60 per cent of the maximum yield in 1893. The following data collected by the Bureau of Internal Revenue for the year 1908 show by municipalities the area of land actually cultivated in sugar, the area of growers' land adapted to such cultivation but not so planted, the area of other land certified by municipal councils as adapted to sugar culture but not planted because of lack of transportation facilities, animals, or capital, and the amount of sugar produced during that year.

² Apuntes de la Isla de Negros. Manila (1894), 11.

Statement showing by municipalities the area of land actually cultivated in sugar, the area of growers' land adapted to such cultivation, the area of other land certified by municipal councils as adapted to sugar culture but not planted because of lack of transportation facilities, and the amount of sugar produced during the year 1908.

Municipality.	Number of growers.	Area of growers' land actually cultivated in sugar.	Area of growers' land adapted to sugar culture but not so planted.	Area of other land not planted.	Piculs of ^{63.25} kilograms.	Metric tons. ^a
Negros Occidental:		<i>Hectares.</i>	<i>Hectares.</i>	<i>Hectares.</i>		
Bacolod	21	794	2,068	1,010	27,846	1,761
Bago	42	2,555	2,871	83,691	5,293	
Binalbagan	14	960	1,575	20,500	1,296	
Cabancalan	12	774	461	1,000	60,002	3,795
Cadiz Nuevo	32	1,684	2,191	1,000	51,452	3,254
Escalante						
Cauayan				2,000		
Ilog	10	858	396	54,802	3,465	
Isabela	29	1,997	1,293	1,500	85,808	5,427
Jimamaylan	19	762	935	34,158	2,160	
Hinigaran	14	579	957	500	20,097	1,271
La Carlota	30	1,887	3,046	270	130,023	8,224
Manapla	25	1,386	2,471	1,900	42,750	2,704
Murcia	13	350	1,401	500	18,970	1,200
Pontevedra ^b	17	850	2,957	950	60,075	3,800
Sagay	7	369	343	300	10,907	690
San Carlos	14	2,080	866	500	76,300	4,825
Saravia	27	1,320	1,862	652	55,215	3,492
Silay	64	2,834	5,367	400	124,476	7,873
Talisay	36	1,800	3,621	59,669	3,772	
Valladolid	8	187	277	120	7,090	448
Victorias	16	722	2,086	1,812	30,096	1,904
Total	450	24,748	37,044	14,414	1,053,927	66,661
Negros Oriental:						
Ayquitán				500		
Bacon				75		
Bais	18	1,688	1,157	20	76,509	4,839
Dauin						
Dumaguete	11	130	234	1,000	4,110	260
Guihulugan	1	300			13,000	822
Larena		5				
Lazi				35		
Siquijor (sub-province)				10		
Tanjay	3	150	110	550	11,900	753
Tayasan						
Tolong	1	75		300	2,000	127
Luzuriaga						
Total	34	2,348	1,501	2,490	107,519	6,801

^a Expressed in nearest whole numbers.

^b Including La Castellana.

Much interesting information which has heretofore not been available concerning the actual condition of the sugar industry of Negros may be deduced from these figures. Thus, in the whole island there was a total of 484 planters, who controlled in all 65,611 hectares of land adapted to sugar culture, of which 27,096 hectares were actually under cultivation and 38,545 for various reasons left unplanted. In addition there were 16,904 hectares of sugar land left unoccupied principally because of the lack of transportation facilities. During the year there were produced a total of 1,161,446 piculs or 73,462 metric tons sugar. Each planter, then, possessed on a average 135.6 hectares of cultivable sugar land, but planted only 56 hectares of it, allowing the remaining 79.6 hectares to lie idle. He produced from the 56 hectares planted 2,400 piculs, or 151.8 metric tons of sugar. Out of a total of 82,545 hectares of land certified to as being well adapted to the culture of the sugar cane 32.8 per cent was actually being cultivated, 46.7 per cent was owned by sugar growers but not planted, and 20.5 per cent was unoccupied, or at least unused because of lack of transportation facilities, animals, or capital. In considering these figures it should be borne in mind that they refer not to the total area of land comprised by the various municipalities, but to that portion of it, generally a small per cent, which is well known and certified to as being fit for cane growing.

Dividing the total production of sugar by the number of hectares planted, we find that the average yield per hectare throughout Negros is 42.9 piculs, or 2.71 metric tons. This question of the average yield has long been a much-disputed point and one which it has been impossible hitherto to state with accuracy. Depending upon the locality which is visited, it is possible to form estimates which may vary several hundred per cent from the truth, in either direction. I have seen cane fields so sparsely sown and of such poor quality as to produce not more than 10 to 15 piculs (0.63 to 0.95 metric tons) to the hectare, while on the other hand there are well-authenticated cases in the richer districts where fields of several hectares in extent have averaged as high as 200 piculs, or 12.6 metric tons, to the hectare. The average yield for the island is greatly reduced by the comparatively large number of small growers who lack either the resources or the ability properly to care for their cane. I may state from personal observation that on a well-managed plantation—and there are a few such in Negros—the yield per hectare under normal conditions of land actually planted in cane will rarely fall below 60 piculs (3.8 metric tons), and frequently comes nearer 70 piculs (4.4 metric tons); this should hold true in the poorer as well as the richer sections, as the difference in quality of soil is in a measure made up for by the fact that cane grown in the former is as a rule richer in sucrose and is replanted every year on fresh soil, whereas in the latter it is allowed to ratoon until the yield becomes greatly diminished.

VARIETIES OF CANE GROWN IN NEGROS.

As far as I have been able to ascertain, the only variety of cane ever grown here to any considerable extent is the so-called "caña morada," or

purple cane. This appears to have been cultivated in Negros for a very long time, as the "oldest inhabitants" at least do not appear to recollect its introduction. It is entirely different from the white or yellow cane common in Luzon, and was quite possibly imported directly to Negros on or about the time of the occupation of the island by the Recoletos. In appearance it is much like the Louisiana Purple, varying in color according to the conditions of its growth from a comparatively light red to a very dark purple. As will be shown later, this cane is extremely sensitive to changes in environment and climate, varying greatly in composition in different sections of the island, but its natural tendency is apparently toward a slender, rather small growth, high in sucrose and purity and comparatively low in fiber. Aside from this variety, a few fields of black cane, and some scattered specimens of the white or yellow variety, there is practically no other kind of cane to be met with in Negros.

CANE DISEASES AND INSECT ENEMIES.

Up to the present time no serious study has been made of this subject. The planters themselves have no knowledge of any fungus or other disease which has ever attacked the cane, and during my stay in Negros I failed to find any indications of diseased cane which would be apparent to, one not a trained plant pathologist.

The only insect enemy recognized by the planters is the so-called "bucan" or "bugan," a grub resembling the larva of the common coconut beetle except that it is smaller. This has been known in Negros for many years, but is not generally thought to do much damage except in certain localities where many ratoons are raised, where considerable loss is sometimes occasioned by its burrowing into and attacking the underground system of the young ratoons, thus stunting the growth of the plant, if not actually killing it.

This is now being made the subject of a separate investigation by the botanical and entomological divisions of the Bureau of Science.

NATIONALITY OF THE PLANTERS.

The haciendas of Negros are owned and managed almost exclusively by Spaniards, Spanish mestizos, or native Visayans. Of other nationalities there are only a few Swiss, one or two Americans, and occasionally a Chinese mestizo. Spanish is the universal language among the hacenderos, and is probably in more common use here than in any other part of the Islands. Practically all of the native planters speak Spanish, while only in exceptional cases is one to be found who understands more than a few words of English.

NATIVE LABOR: DIFFICULTIES, PAST AND PRESENT.

The necessary laborers for taking off a sugar crop are, excepting in the rare instances where a sufficient number live on the hacienda, imported each year, by contract for the season, from the neighboring Islands of Panay and Cebu. They are all Visayans, those on the west coast speaking the Panayano and on the east the Cebuano dialect. Labor is paid for at an average rate of 25 centavos, Philippine currency, per day, with rations furnished by the hacienda, and costing about 15 centavos extra per man each day. This is the commonly accepted wage throughout the island, the extreme limits being 25 centavos without rations and 50 centavos without rations. Complaint is universal over the difficulty of obtaining a sufficiency of labor. This is occasioned largely by the abnormal conditions prevailing in Negros during the milling season, when, because each small planter has his own mill and grinds his own cane, an excessive number of laborers is required for a few months in the year only; during the remainder less than half this number is necessary. As a result, the planter who can not afford to keep on his plantation for the entire year men whom he only needs for the grinding season is forced to arrange with labor contractors to bring the necessary extra men in from other parts of the country, and as an additional inducement to advance 10 to 25 pesos (5 to 12.50 dollars, United States currency) for each man desired. Breaches of faith by contractors after receiving advance money are frequent, and numerous instances are cited where out of twenty or thirty men reporting for work and receiving a month's wages in advance, half have escaped within the week. The planters complain that it is almost impossible legally to compel a man to work, even though payment for his services has been given him in advance and under a written contract. The man, if apprehended, admits the debt and declares his willingness to repay it in cash as soon as he can secure the money, lamenting at the same time his present inability to do so. Since imprisonment for debt is no longer possible, he must be set at liberty to go to some other hacienda and repeat the same process. On the other hand, the custom of giving laborers advance money is such a long-established one that the planter who refuses to do so finds it extremely difficult to secure enough men to carry him through the grinding season. This labor difficulty is so serious throughout Negros, as several planters have informed me, that they annually lose more money in this way than through all other causes combined. Year by year, it is complained, as men find out that they can break contracts and go unpunished, the practice is becoming more prevalent. However, this ambition on the part of the native laborer to obtain money without rendering its due equivalent has not entirely been brought about by American influence, as is sometimes insinuated; this is shown by the fact that even in prosperous times under

the Spanish régime it was the cause of serious complaint. Echaúiz³ treats of this particular phase of the labor problem together with other troubles of the hacendero. His remarks, although somewhat lengthy and poetically expressed, are worthy of quotation as showing that the sugar grower had much the same difficulties to contend with then as now. The following is a free translation from page 82 of this book:

"The planter, compelled by the harsh and imperious law of custom and of lack of capital, a law more forceful and obligatory than any officially sanctioned and published, is at once farmer and manufacturer; he cultivates the fields, and busies himself with making sugar by short and simple methods, operations in field and sugar house during certain months in the year being carried on simultaneously, conditions which force him to pay out enormous sums of money and to borrow at usurious rates. Not until there shall be established central haciendas on extensive estates, until the farmer be allowed to remain farmer and the manufacturer to occupy himself solely with his factory, will the sugar planter prosper as he should, notwithstanding the fertility of our soil, the cheapness of labor, and the large yields obtained here as compared with those in the Peninsula (Spain).

"But these difficulties are as nothing compared to one of greater moment, which most prejudices the farmer's welfare, which, unless an energetic remedy is taken, or a law set forth binding on everyone, will put an end to agriculture in the Island of Negros—the question of laborers.

"This island, for its cultivation, already so intensive, for its progress, ever greater, needs a multitude of laborers. Enough, perhaps, dwell within its boundaries, but will not work, preferring to enjoy the abundance of plains and mountains plentiful with fruit, of rivers and of seas, which for slight effort yield to man his daily sustenance. The lack of laborers on the island makes it necessary to seek them from other provinces.

"The month of September arrives, and the planter gazes with admiration on a bountiful harvest; his complacency is without limit; passing from field to field, he thinks of the number of piculs he is on the point of harvesting, but, in the midst of a state of mind so satisfactory, a doubt assails him, he is perplexed by one thought—laborers are needed—and to remedy this difficulty, thirty or forty thousand pesos are sent off to the Island of Panay. November comes; December, January, and the promises made when he sent off the money are not yet fulfilled. Neither the number of laborers agreed upon nor the pesos advanced to them put in their appearance.

"Twenty or thirty well-clad individuals present themselves at the sugar house, speak with the foremen and express a desire to go to work, because, as they say, they know the planter has a kindly disposition and treats his men well, demanding, at length, after a large amount of talk, from seven to ten pesos apiece, which they need to buy cedulas, pay taxes, or to support their families. The hacendero grasps at this unforeseen opportunity, builds up new hopes on the strength of the reinforcement, and hands over the money, and the surprise comes next day when he finds himself without workmen and without coin. The laborers who presented themselves the day before have disappeared during the night.

"This actually happens in Negros, and there is urgent need of a speedy and efficacious remedy for an evil which, if allowed to spread, may ruin the work of many years. Regulations should be made regarding hours of work, wages which must be paid, rations, voyages, time of stay in each hacienda, but, at the same time, let some guaranty be given to capital, some security to the planter."

³ *Loc. cit.*

THE PRINCIPAL SUGAR-PRODUCING DISTRICTS OF NEGROS.

SILAY.

In this district may be considered to lie the entire stretch of land extending from the town of Victorias southward to the southern limits of the municipality of Talisay, a district having a length in a direct line of 25 kilometers and varying in width from 5 to 15 kilometers from the seacoast to the hills. Of the four municipalities included therein, Saravia, Silay, and Talisay are most closely connected, being situated in a direct line along the main provincial road, which affords a ready means of intercommunication during the entire year. From Saravia eastward to Victorias the roads are not so good, several small streams are as yet unbridged, and traveling is in the main restricted to the dry season. However, road-building work is progressing steadily, and it is expected that within a short time the provincial highway will have been extended to Victorias. As it is, land-transportation facilities are better in the district around Silay than in any of the other sugar centers of Negros, first, because of the lack of large rivers affording means of communication by water, and, second, owing to the fact that this portion of the island has been settled for the longest time. Here, in the early sixties, were established the first large haciendas founded on capital supplied by Iloilo merchants, and in this section the local sugar industry for a long time made its most rapid advances. Even at the present day this district leads all others in point of total production and in number of plantations, although not in yield of sugar per hectare. The following data regarding sugar land and production in this section in 1908, calculated from the statement of the Bureau of Internal Revenue previously quoted, are, for more ready reference, rearranged here.

Area and production of the Silay district.

	Amount	
	<i>Hectares</i>	<i>Per cent.</i>
Number of growers in the district, 143.		
Area of growers' land actually cultivated in sugar.....	6,676	29.7
Area of growers' land adapted to sugar culture but not planted.....	12,936	57.5
Area of other land adapted to sugar culture but not planted.....	2,864	12.6
Total available sugar land.....	22,476	
Average area of land per planter:		
Planted.....	46.7	
Not planted.....	90.5	
Total.....	137.2	
	<i>Piculs.</i>	<i>Metric tons.</i>
Total sugar produced.....	269,456	17,043
Average amount of sugar produced per planter.....	1,884	119.2
Average yield of sugar per hectare.....	40.4	2.5

It will be noted, on comparing these figures with those for the entire island, that although each planter in this district possesses a trifle more land than the average grower throughout the island, he produces from it much less sugar—119.2 metric tons, as compared with 151.8, the general average. This is due not so much to a smaller yield of sugar per hectare as to the fact that of the total land owned by sugar planters, a much smaller proportion is each year planted in cane. As in most other places, lack of capital is responsible for much of the idle land, but the trouble here seems to lie largely in the land itself, much of which has become so exhausted through sixty-odd years of continuous cultivation with scarcely any attempt at replenishing its fertility that at the present day it may be relied upon to yield only one crop every two or three years; during the remainder of the time it is allowed to lie fallow.

Below are given analyses of typical soils throughout the district.

The field samples of these and all subsequent analyses were carefully taken with a soil auger, under my personal supervision, and each number represents a composite of from two to five individual samples taken from different parts of a field. The surface soils were taken to a depth of 20 centimeters, except in the relatively few instances where a decided change in composition was apparent at a less depth. The "subsoils," generally a mixture of subsurface and true subsoil, were taken through a stratum of 25 centimeters, commencing at the point where the first noticeable difference from the surface soil was encountered. In cultivated fields this difference occurs as a rule at a depth of from 20 to 30 centimeters, and is fairly easy to detect, long-continued plowing through many years having so thoroughly mixed and altered the top layer that a decided change in composition or texture is noted once the plow line is passed. In spite of many rumors and traditions of "ten-foot" soils in Negros, only a very few instances have occurred where a true subsoil could not be encountered within at least 60 centimeters of the surface. In sampling freshly plowed fields, or fields containing growing cane, a portion of soil from the top of a furrow or row was first scraped away, so that the sample started at about the average level of the field.

The chemical analyses of these soils were made substantially according to the methods of the Association of Official Agricultural Chemists, and results are expressed as percentages of the soil dried to constant weight. All determinations except potash, soda, and "volatile matter" were made by L. A. Salinger and R. R. Williams, of the Bureau of Science.

Mechanical analyses of a large numbers of these soils were made by Mr. Wallace E. Pratt, of the Division of Mines, using the centrifugal method as outlined in Bulletin No. 24, United States Department of Agriculture, Division of Soils. For this work the air-dried samples as prepared for chemical analysis were employed.

Soil analyses, district of Silay.

Soil No.	Nature of soil.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Volatile matter.	Remarks.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
50	Surface	97.7	0.06	0.08	0.15	0.12	0.05	0.06	5.31	Hacienda Buen Retiro, Silay. Considered very good sugar land; said to yield about 110 piculs (7.0 metric tons) of No. 1 sugar per hectare. Has been under cultivation for more than fifty years. Does not yield ratoon crop. Surface soil light loam; subsoil at 20 centimeters, yellow sand and clay; at 50 centimeters, nearly all sand.
50 A	Subsoil	98.4	0.07	0.07	0.47	0.36	0.04	0.03	7.35	
51	Surface	96.3	0.05	0.04	0.46	0.48	0.05	0.06	4.66	Hacienda Buen Retiro, Silay. Poor, exhausted and, yield said to be about 35 piculs (2.2 metric tons) per hectare. Has been cultivated more than fifty years. Surface soil in appearance much like No. 50. Subsoil at 25 centimeters, white clay mixed with coarse reddish sand and small pebbles.
51 A	Subsoil	92.0	0.04	0.06	0.49	0.50	0.04	0.06	8.21	
52	Surface	97.8	0.03	0.08	0.51	0.25	0.08	0.06	4.14	Hacienda Binonga, La Paz. Exhausted land, hardly worth planting, as yield is very small. Customary to plant every two years, letting land lie idle in alternate years. Subsoil at 20 to 25 centimeters, white clay with coarse reddish sand.
52 A	Subsoil	89.8	0.03	0.04	0.50	0.35	0.03	0.06	8.33	
53	Surface	98.9	0.04	0.11	0.51	0.54	0.06	0.06	5.33	Hacienda de D. Cuenca, Talisay. Fair land, said to yield 60 piculs (3.8 metric tons) per hectare. Subsoil at 20 centimeters, brown clay and coarse reddish sand and pebbles; at 50 centimeters, mostly sand.
53 A	Subsoil	91.9	0.06	0.12	0.52	0.47	0.04	0.06	7.40	
54	Surface	99.0	0.06	0.07	0.50	0.14	0.06	0.09	6.19	Hacienda Tabigui, Saravia. Fair soil, said to yield 100 piculs (6.33 metric tons) per hectare of Number 1 sugar. Cane grows quickly and ripens in eleven months. Formerly a river passed over this field. Surface soil slightly sandy loam; subsoil at 25 centimeters, sand and clay, at 50 centimeters, much sand but finer than that of Silay.
54 A	Subsoil	95.1	0.04	0.06	0.49	0.36	0.05	0.09	7.23	
55	Surface	97.8	0.04	0.11	0.67	0.55	0.07	0.13	8.02	Hacienda Tabigui, Saravia. "Tierra baja." Heavier soil than No. 53, more clay. Here cane ripens more slowly. Large cane, but can not produce better than Number 3 sugar. Needs thirteen to fourteen months to ripen. Subsoil at 20 to 25 centimeters, lumpy stiff, whitish clay with a very little red sand in streaks, clay becomes whiter with increase of depth.
55 A	Subsoil	93.7	0.03	0.13	0.74	0.49	0.11	0.07	8.23	
56	Surface	99.7	0.05	0.08	0.45	0.51	0.06	0.11	8.11	Hacienda Tabigui, Saravia. Intermediate in appearance between Numbers 54 and 55. Cane ripens in twelve months. Subsoil at 15 to 30 centimeters, a mixture of clay and sand.
56 A	Subsoil	99.9	0.04	0.06	0.40	0.40	0.04	0.08	9.86	

Soil analyses, district of Silay—Continued.

Soil No.	Nature of soil.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Volatile matter.	Remarks.
		Perct.	Perct.	Perct.	Perct.	Perct.	Perct.	Perct.	Perct.	
57	Surface	99.9	0.04	0.12	0.76	0.53	0.08	0.19	6.54	Hacienda Toreno; old town, Victorias. Average cane land of this district. Cane ripens in eleven to twelve months. Said to yield 75 piculs (4.75 metric tons) per hectare of Numbers 1 and 2 sugar. Subsoil at 20 to 25 centimeters, whitish clay mixed with reddish yellow sand; at 50 centimeters, nearly all sand.
57 A	Subsoil	100.0	0.03	0.17	0.76	0.63	0.06	0.15	6.21	
58	Surface	99.7	0.04	0.03	0.11	0.11	0.10	0.16	11.88	Hacienda Esperanza, Victorias, new town (Manapla side). Average land of this district, but very poor soil apparently. Surface reddish brown clay; subsoil at 25 centimeters, a little stiffer clay than at surface; some sand.
58 A	Subsoil	99.7	0.03	0.02	0.14	0.13	0.10	0.12	14.90	
59	Surface	99.9	0.07	0.17	0.76	0.68	0.10	0.17	5.29	Hacienda Lucuay, near town of Silay. One of the oldest cultivated lands in this district; said to yield about 90 piculs (5.7 metric tons) of Number 1 sugar per hectare of plant cane. Surface somewhat sandy loam; subsoil at 20 to 25 centimeters, considerable yellow sand; at 50 centimeters, nearly all sand.
59 A	Subsoil	99.9	0.07	0.16	0.73	0.76	0.07	0.15	5.18	

Soil No.	Nature of soil.	Detritus on 1-mm. screen. Mechanical analyses of samples (5 grams) of material, district of Silay, passing a 1-mm. screen. Samples as prepared for chemical analysis.								Total.
		>1 mm., gravel.	1.0-0.5 mm., coarse sand.	0.5-0.25 mm., medium sand.	0.25-0.10 mm., fine sand.	0.10-0.05 mm., very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.		
50	Surface	2.3	0.74	5.30	20.60	27.94	29.70	15.56	99.84	
50 A	Subsoil	1.6	0.74	5.10	19.32	24.04	27.48	23.40	100.08	
53	Surface	6.1	3.06	12.50	20.28	20.32	26.86	16.34	99.36	
53 A	Subsoil	8.1	2.20	9.72	18.14	19.94	25.02	25.22	100.24	
55	Surface	2.2	0.22	0.84	2.91	23.84	58.01	13.55	99.37	
55 A	Subsoil	6.3	1.00	2.22	4.05	18.06	59.28	15.26	99.87	
58	Surface	0.3	0.55	1.57	5.01	8.56	31.38	52.86	99.93	
58 A	Subsoil	0.3	0.37	1.32	5.15	9.64	30.74	52.32	99.52	
59	Surface	0.1	0.14	3.50	24.98	36.72	22.02	12.68	100.04	
59 A	Subsoil	0.1	0.20	4.10	24.32	31.52	24.02	12.94	100.10	

The average composition of the soil in this district, from the above table, is as follows:

Chemical composition.

Nature of soil.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO	P ₂ O ₅ .	N.	Volatile matter.
Surface	98.17	0.05	0.09	0.52	0.45	0.09	0.11	6.55
Subsoil	96.04	0.04	0.09	0.52	0.45	0.06	0.09	8.29

Physical composition.^a

Nature of soil.	>1 mm., gravel.	1.0-0.5 mm., coarse sand.	0.5-0.25 mm., medium sand.	0.25-0.10 mm., fine sand.	0.10-0.05 mm., very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.	Total.
Surface	2.2	0.94	4.74	14.76	23.48	33.59	22.20	99.71
Subsoil	3.3	0.90	4.49	14.20	21.24	33.31	25.83	99.97

^a Since a less number of samples were taken for the mechanical analyses, their average is not strictly comparable with that of the chemical analyses.

This soil is, on the whole, decidedly poor in all the elements of soil fertility, with the exception of lime, which is present in a fairly large amount, although not large as compared with other parts of the island. In this case chemical analysis is well borne out by practical experience, as Silay is generally considered to be the poorest of the large sugar districts. The majority of the plantations here are in what might be called a "semi-exhausted" condition; that is, the land through cultivation has reached that stage where it will no longer yield ratoon cane, nor in many cases consistently produce good crops of plant cane without rotation and fertilization. Of course, there is still sufficient fertility left in these soils so that they might go on bearing cane for the next fifty years without becoming completely worn out, even under the present system of cultivation, but the probabilities are that the yield would diminish steadily until finally they would not be worth cultivating. By this is not meant that these soils are necessarily doomed eventually to become barren. Enormous crops of sugar are, in other countries, raised on lands but little better than these. With more careful cultivation, the consistent return to the fields in the shape of bagasse ash and animal manure of the potash, phosphoric acid, and nitrogen taken from them, together with eventual green manuring and rotation, there is no reason why these lands should not go on producing good crops of cane almost indefinitely and with little need of recourse to artificial fertilizers. The point is that they, unlike some other parts of Negros, have reached that stage where they no longer stand abuse.

Individually, very little difference can be detected in these soils. Chemical analysis at its best gives only a very rough approximation of a soil's productive power, as, owing to its physical condition or the state of combination of its constituents, an apparently very poor soil may have available sufficient plant food to produce much larger crops than one which, chemically considered, is its superior. Take numbers 50 and 51, for instance: Both are from the same hacienda, both have been cultivated for over fifty years, and in chemical composition they are very nearly identical, yet number 50 is said to produce more than three times as much sugar per hectare as number 51. Numbers 57, 58, and 59 are decidedly high in nitrogen, for this district. They have very probably been treated with animal manure.

All these samples were obtained so late in the grinding season that I had no opportunity personally to examine the cane produced in this region, and the figures given as to the quality and quantity of sugar produced from the different soils are simply approximations made by the planters themselves. The general tendency in such cases is toward over-, rather than underestimation.

The quality of sugar produced in Silay is somewhat better than in most other districts, it being largely "No. 1" and "No. 2." This in itself is considered an indication of a not too fertile soil, since the smaller canes produced yield normally a juice of higher purity and, by the local process of manufacture, a better sugar than the more luxuriantly grown canes of richer districts.

For shipment to Iloilo the sugar is handled in bull carts to the nearest lorch landing on the coast at a cost of from 5 to 25 centavos a picul, 0.79 to 3.96 pesos a metric ton, according to distance. As Silay is situated nearer to Iloilo and is more conveniently located than other sugar centers, the freight rate is correspondingly lower, averaging 15 centavos per picul, or 2.38 pesos per metric ton.

BAGO.

Southward, along the provincial road from Talisay through Bacolod, the capital of the Province of Occidental Negros, the land becomes gradually poorer in quality, and this section is, at present, of relatively little importance as a sugar producer, although in former times it was quite extensively and profitably cultivated. The greater part of the land around Bacolod, probably less fertile in the beginning, is much further advanced along the road to complete worthlessness than that of Silay, and much of it has already passed the stage where it will yield returns sufficient to pay for planting in cane. From Bacolod, extending nearly to the town of Bago, a distance of some 20 kilometers, a strip of land is found which in the main is almost absolutely

barren and unfit for cultivation of any kind. A typical analysis of this kind of soil is included under those of Bago.

The sugar soils of Bago are restricted to a narrow strip of land 2 or 3 kilometers in width, along the Bago River from its mouth to its junction with the Malacandang River, near the hacienda San Juan del Monte, a distance from the coast of 12 kilometers; thence spreading out into the larger, but more rolling, triangular section between the Bago and the Malacandang Rivers, comprising the barrio of Maa, and on up to the foot of the mountains. The distance in a direct line from the seacoast to the hacienda Progreso, farthest to the interior of the district, is 26 kilometers. The Bago River is navigable by sugar lorchas at high tide for 7 kilometers up to the hacienda Lumañgub, although two days are generally required for the trip. A sand bar at the mouth of the river prohibits entrance except just at the height of the tide, and by the time this has been passed the water has again fallen so that it is necessary to wait twenty-four hours before proceeding up the river. Haciendas lying inland from Lumañgub are obliged to bring their sugar down in bull carts to this point for shipment to Iloilo; and this at considerable expense, owing to roads which, while passable in dry weather, are, after a little rain, absolutely useless. The cost of transporting sugar by bull cart from Progreso to the lorchalanding at Lumañgub is 30 centavos per picul, or 4.75 pesos a metric ton. Adding 20 centavos more as the cost of shipping to Iloilo, this makes a total of 50 centavos per picul, or 7.90 pesos a metric ton, for transportation charges alone, about three-fourths the cost of freight from Iloilo to New York. Owing to the excessive cost for transportation, sugar growing has been abandoned as profitless in many of the plantations of the interior of the Bago district, although, in other respects, sugar may be produced at less expense here than in the majority of other parts of the island. The better cultivated lands, therefore, are confined to the narrow strip adjoining the navigable portion of the Bago River. The best lands lie close along the river on the north bank, where the soil is an alluvial, more or less sandy loam, becoming heavier with increasing distance from the river, until, at about 1 kilometer, low land made up of heavy clay is encountered. This, because of lack of drainage, is very sticky and difficult to work properly; it is therefore used chiefly for rice culture. A kilometer farther on, the land rises again, and from here to Bacolod lies the rocky, barren region previously mentioned. South of the river conditions are much the same—about a kilometer of good sugar land, shading off gradually into heavy clay and paddies, but rising again, after a few kilometers, to form the municipalities of Valladolid and La Carlota.

The following data give the area of land and production of sugar in Bago during 1908:

Area and production of the Bago district.

	Amount.	
	<i>Hectares.</i>	<i>Per cent.</i>
Number of growers in the district, 42.		
Area of growers' land actually cultivated in sugar	2,555	47.1
Area of growers' land adapted to sugar culture but not planted	2,871	52.9
Total available sugar land	5,426	
Average area of land per grower:		
Planted	60.8	
Not planted	68.4	
Total	129.2	
	<i>Piculs.</i>	<i>Metric tons.</i>
Average of sugar produced	1,993	126.1
Average yield of sugar per hectare	32.8	2.07
Total sugar produced	83,691	5,293

The average grower of this district, while owning somewhat less sugar land than is the general average for Negros, has considerably more of it planted in cane. The decidedly low yield per hectare of land is brought about by inefficient cultivation because of lack of capital in many haciendas. In this district, moreover, the yield per hectare computed from these figures is probably much further from the true average yield than in other localities. The year 1908 was a decidedly poor one for Bago, while, on the contrary, a considerably greater amount of land had been planted for the year 1909, as will be shown by the following figures:

Total yield of sugar.

	<i>Piculs.</i>
1907	91,775
1908	83,691
1909 (estimated)	103,620

The only figures available over the whole island for calculating the yield per hectare were the area of land planted for 1909 and the total production in 1908, which, taken as a whole, give fairly correct results, although a trifle low, but in the case of Bago, in particular, they lead to an erroneous conclusion. Assuming the estimated yield for 1909 to be the true one, the yield per hectare in Bago would be 40.6 piculs, a figure more nearly approximating that for the whole of Negros. In addition, some of the figures reported from Bago were decidedly irregular, due probably to some misconception on the part of the planters as to the information desired. The Government was obliged to depend for this information almost entirely upon statements made by the planters themselves, and I know of at least one instance where the yield per hectare of land planted, calculated from a planter's statement, averaged only 20 piculs, whereas I have positive knowledge that ordinarily it would run nearly 60.

In quality, the sugar produced here is, as a rule, superior. According to analyses of cane, quoted later, it should be nearly all "No. 1," but, owing to poor work in the sugar houses and often to lack of facilities for cutting cane at the proper time, a considerable amount of low-grade sugar is also made.

The following are analyses of representative Bago soils, taken throughout the district from near the coast up to the hacienda farthest inland.

Soil analyses, district of Bago.

Soil No.	Nature of soil.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Volatile matter.	Remarks.
		Perc.	Perc.	Perc.	Perc.	Perc.	Perc.	Perc.	Perc.	
14	Surface	98.4	0.11	0.08	0.48	0.25	0.10	0.09	9.71	Hacienda San Esteban, Maligán; best land near Bago River. Light loam, a trifle sandy. This field was treated with lime in 1908. Said to yield about 75 piculs (4.75 metric tons) of No. 1 sugar per hectare. Subsoil begins at a depth of from 40 to 60 centimeters, a mixture of reddish clay and sand, sandier as it becomes deeper.
14A	Subsoil	98.3	0.08	0.10	0.50	0.36	0.11	0.06	8.63	
15	Surface	98.8	0.08	0.08	0.40	0.38	0.07	0.10	8.91	Hacienda San Esteban, Maligán, poor land, about 1 kilometer from river. Light loam, white when dry. Canes growing here are very small and sparsely grown. Subsoil begins at from 15 to 35 centimeters, a stiff clay mixed with coarse yellow sand in streaks; at 60 centimeters, white, very stiff clay, with rather more streaks of sand.
15A	Subsoil	98.5	0.08	0.08	0.41	0.43	0.06	0.08	10.48	
16	Surface	99.7	0.10	0.10	0.80	0.48	0.11	0.08	7.61	Hacienda Alegria. This is said to be the richest land in the district of Bago. Samples taken about 1 kilometer from the river. Not the best field in the hacienda, but very good, said to yield 125 piculs (7.9 metric tons) of No. 1 sugar per hectare. Light, almost sandy loam. Subsoil of clay and sand begins at from 20 to 60 centimeters, although in spots the surface soil continues practically unchanged down to 80 centimeters.
16A	Subsoil	99.7	0.11	0.07	0.63	0.56	0.11	0.06	8.40	
17	Surface	99.9	0.12	0.05	0.36	0.39	0.08	0.09	8.94	Hacienda Lumanigub. Good cane land, about 200 meters north of Bago River. Said to yield about 100 piculs (6.33 metric tons) per hectare. Subsoil at about 35 centimeters, fairly stiff clay with some sand, sand increasing with depth.
17A	Subsoil	98.8	0.12	0.05	0.38	0.43	0.08	0.08	10.21	
18	Surface	97.4	0.09	0.07	0.37	0.49	0.08	0.08	7.39	Hacienda Santo Domingo, south side of Bago River. A good average cane land, said to yield about 85 piculs (5.38 metric tons) per hectare. Soil is a light powdery loam, very light colored when dry; subsoil at 25 centimeters, whitish clay with coarse yellow sand in streaks.
18A	Subsoil	98.3	0.10	0.08	0.55	0.28	0.10	0.06	10.47	

Soil analyses, district of Bago—Continued.

Soil No.	Nature of soil.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Volatile matter.	Remarks.
		Perct.	Perct.	Perct.	Perct.	Perct.	Perct.	Perct.	Perct.	
19	Surface	99.8	0.11	0.13	0.62	0.31	0.13	0.09	8.36	Hacienda San Juan del Monte, best field in the hacienda 300 meters from river. This field was once measured and the sugar made from it weighed. It is said to have yielded 116 piculs (7.35 metric tons) per hectare. Surface soil light loam; subsoil at about 35 centimeters, brownish clay and yellow sand well mixed.
19 A	Subsoil	99.8	0.12	0.10	0.66	0.21	0.11	0.07	8.72	
20	Surface	94.2	0.07	0.09	0.35	0.36	0.07	0.07	6.25	Hacienda San Juan del Monte; worst land, 1 kilometer from river, not planted this year. Last season yielded about 50 piculs (3.16 metric tons) per hectare. Rather stiffer soil than No. 19. Owner says that after a rain this field can not be plowed for three days, while No. 19 can be plowed the next day. Subsoil mostly very stiff clay, wet even in dry weather; below 50 centimeters, some gravel.
20 A	Subsoil	92.3	0.06	0.07	0.42	0.33	0.03	0.05	7.73	
21	Surface	97.8	0.28	0.12	0.58	0.37	0.33	0.18	8.66	Hacienda Lumanabub. Virgin soil, planted for the first time two years ago. Originally an old sugar mill on this spot. Cane grows very large and luxuriantly here, but nearly all fallen down and yields a very poor quality of sugar. Soil a light loam, inclined to be sandy; subsoil at 60 centimeters, very little difference from surface, perhaps a trifle more clay.
21 A	Subsoil	99.8	0.27	0.10	0.45	0.24	0.16	0.06	7.72	
22	Surface	98.2	0.08	0.02	0.08	0.07	0.09	0.07	14.20	Hacienda Zaragoza. Red clay, said to be poor soil for cane, as it grows large but watery. Subsoil at 25 centimeters, stiff red clay, which continues down at least 2 meters.
22 A	Subsoil	98.4	0.07	0.02	0.10	0.07	0.06	0.03	14.19	
23	Surface	98.0	0.07	0.05	0.24	0.08	0.05	0.11	9.15	Hacienda Zaragoza. White clay, near river, said to be poor soil for cane. Has been planted only to rice. Subsoil at 10 centimeters, very stiff white clay.
23 A	Subsoil	98.4	0.10	0.08	0.55	0.02	0.07	0.06	11.11	
24	Surface	98.9	0.16	0.07	0.20	0.01	0.07	0.16	12.20	Hacienda Progreso. High land, best cane soil, said to yield Nos. 1 and 2 sugar. Soil light loam, slightly yellowish tinge and many stones. This hacienda is the farthest interior, toward the mountains, in the Bago district. Subsoil at about 25 centimeters, brownish clay and sand; below 60 centimeters, some gravel.
24 A	Subsoil	99.2	0.14	0.07	0.19	0.09	0.10	0.10	11.93	
25	Surface	99.7	0.15	0.03	0.19	0.06	0.14	0.11	14.80	Hacienda Progreso. Lower land, but much the same general appearance as number 24. Said to yield much cane, but a poor quality of sugar, No. 3 and "corriente."
25 A	Subsoil	99.7	0.15	0.03	0.15	0.02	0.13	0.09	13.20	

Soil analyses, district of Bago -Continued.

Soil No.	Nature of soil.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Volatile matter.	Remarks.
		Perct.	Perct.	Perct.	Perct.	Perct.	Perct.	Perct.	Perct.	
26	Surface	99.5	0.17	0.07	0.21	(*)	0.07	0.15	11.62	Hacienda Begonia. Soil much the same in appearance as numbers 24 and 25. Said to yield Nos. 2 and 3 sugar
26 A	Subsoil	99.6	0.13	0.08	0.21	0.02	0.07	0.09	11.72	
27	Surface	99.2	0.06	0.10	0.52	0.24	0.03	0.05	4.39	Hacienda Consorcia, 4 kilometers north of the town of Bago on Bacolod road. Exhausted soil, yield very small, probably not more than 15 piculs (0.95 metric ton) sugar per hectare. Soil is a light sandy loam; subsoil at 25 centimeters, nearly all sand with a little reddish clay; at 80 centimeters, sand and gravel.
27 A	Subsoil	99.2	0.03	0.12	0.56	0.31	0.03	0.05	4.62	
28	Surface	97.0	0.03	0.03	0.30	0.21	0.06	0.06	11.30	Sample of poor land about 2 kilometers north of Bago River. Stony and full of gravel; has never been cultivated. Subsoil 15 centimeters, slate-colored clay.
28 A	Subsoil	97.1	0.02	0.06	0.38	0.03	0.03	0.05	12.11	

* Trace.

Soil No.	Nature of soil.	Detritus on 1-mm. screen.	Mechanical analyses of samples (5 grams) of material district of Bago, passing a 1-mm. screen. Samples as prepared for chemical analysis.						
		>1 mm., gravel.	1.0-0.5 mm., coarse sand.	0.5-0.25 mm., medium sand.	0.25-0.10 mm., fine sand.	0.10-0.05 mm., very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.	Total.
14	Surface	1.6	1.36	5.50	12.72	22.10	32.30	25.76	99.74
14 A	Subsoil	1.7	1.68	6.94	11.78	16.24	32.64	27.04	99.32
15	Surface	1.2	1.36	5.68	9.92	17.00	39.46	26.32	99.74
15 A	Subsoil	1.5	1.76	5.94	10.64	14.08	38.52	29.26	100.20
16	Surface	0.3	0.42	3.40	13.58	26.58	35.64	20.12	99.74
16 A	Subsoil	0.3	0.34	2.60	14.76	27.00	37.92	16.56	99.18
17	Surface	0.1	0.26	2.18	9.20	18.82	40.40	28.64	99.50
17 A	Subsoil	0.2	0.22	2.34	12.10	20.12	39.74	24.84	99.36
18	Surface	2.6	1.74	4.20	6.54	19.74	43.12	23.80	99.44
18 A	Subsoil	1.7	1.76	2.46	8.08	19.84	40.78	27.26	100.18
19	Surface	0.2	0.16	1.08	11.76	35.58	33.50	18.34	100.42
19 A	Subsoil	0.2	0.04	0.72	14.94	34.82	37.62	11.78	99.92
21	Surface	2.2	0.50	2.28	11.10	36.62	35.62	10.88	100.00
21 A	Subsoil	0.2	0.04	0.78	19.46	35.50	32.14	12.06	99.98
24	Surface	1.1	2.30	10.78	14.16	13.06	29.38	30.36	100.01
24 A	Subsoil	0.8	2.12	7.42	10.10	9.52	31.28	39.66	100.10
25	Surface	0.3	1.28	5.12	8.40	11.76	38.44	35.26	100.26
25 A	Subsoil	0.3	0.60	2.84	8.72	8.88	33.20	46.04	100.28
27	Surface	0.8	5.94	30.32	26.62	11.76	12.28	13.34	100.26
27 A	Subsoil	0.8	3.94	26.52	26.36	10.52	15.22	17.56	100.12

These soils average in composition as follows:

Chemical composition.

Nature of soil.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Volatile matter.
	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
Surface	98.43	0.11	0.07	0.38	0.25	0.10	0.10	9.57
Subsoil	98.47	0.11	0.07	0.41	0.23	0.07	0.07	10.08

Physical composition.

Nature of soil.	>1 mm., gravel.	1.0-0.5 mm., coarse sand.	0.5-0.25 mm., medium sand.	0.25-0.10 mm., fine sand.	0.10-0.05 mm., very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.	Total.
	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
Surface	1.0	1.53	7.05	12.70	21.30	34.04	23.28	99.91
Subsoil	0.8	1.25	5.86	13.99	19.65	33.91	25.21	99.86

Although not of a high degree of fertility, they are considerably better than those of Silay, especially as regards potash, and they may be classed as thoroughly dependable sugar soils where plant cane alone is to be grown. There is apparently not a sufficient excess of readily assimilable plant food present in them to render ratooning very profitable, although this is done to a very limited extent, especially in the newer lands. The Bago soils carry less lime than those of any other part of Negros, and this fact, in the clay soils at least, probably accounts for the increased difficulty experienced in cultivating them, as they have a tendency when wet to become very sticky and hard to plow; and if plowed while wet they clump together into compact masses which, once dry, are very difficult to break up. As in other districts, analytical differences between so-called good and poor soils are comparatively slight. However, once having established a normal type of soil for a certain district, the relative value of any other soil from the same district may be predicted with some degree of accuracy, provided its physical conditions are at the same time known.

For example, numbers 14 and 15, a "good" and a "bad" soil from the same hacienda, are very much alike chemically, number 14 being very slightly superior in percentage of potash, lime, and phosphoric acid. The chief difference lies in the fact that the subsoil of number 15, fairly close to the surface, is made up of very stiff clay, with only a little coarse sand in streaks, which does not afford sufficient drainage, while that of number 14 begins well below the plow line, and is rather more open in texture.

Chemical analysis shows to better advantage in the case of numbers 19 and 20, samples taken from the best and from the worst field in the same plantation,

number 19 being noticeably superior in every constituent, and especially so as regards lime. Of course, the greater permeability of number 19 has much to do with its superiority, but this difference in physical characteristics is probably brought about to some extent by the larger amount of lime which number 19 carries, the value of lime in a soil being due not so much to the nutriment it affords a plant as to the beneficial effect it has on the physical character of the soil itself, keeping it light and porous, and, in the case of a heavy clay, preserving its tilth by acting as a colloid precipitant and destroying its tendency to form a plastic mass.

The general average of the soils from Bago, as given above, may be taken as just about the normal type for this district from a chemical point of view, anything running much below this in potash, lime, phosphoric acid, and nitrogen being in all probability not very productive. Numbers 27 and 28, characteristic types of the poor land between Bago and Bacolod, are practically valueless for cane growing, as may readily be seen from their analyses. Number 21 is a curious example of a soil which is considered to be too rich for cane. This particular field was, in former times, the site of an old sugar mill, with its surrounding "plaza" for sun drying bagasse, and the comparative richness of the soil here is undoubtedly due to the bagasse ash, scums, trash, etc., which such a place in time accumulates. Quite recently the old sugar house was torn down and the land planted for the first time in cane. This soil, while very much richer than any other in Bago, is not superior to good cane soils from other districts of Negros except in its phosphoric acid content, and, chemically speaking, there is *a priori* no reason why it should not produce a good quality of sugar. Mechanical analysis shows it to be made up largely of very fine sand and silt, with relatively little clay, a condition tending toward rapid growth, but a less sweet cane. The cane found growing here will be considered later under "Other varieties of cane grown in Negros," as, although it really belongs to the common purple or native variety, its composition is so different from that ordinarily grown in Bago that to include it in the table of analyses of canes grown in this vicinity would considerably alter their general average.

ANALYSES OF CANE FROM THE DISTRICT OF BAGO.

The method employed in sampling and analyzing cane from this and other districts was practically the following:

Twenty canes were collected from a field at the time its soil was sampled, five, as a rule, being cut from individual stools growing near the spots where each of the four samples of soil was taken. No especial care was taken except as nearly as possible to select representative samples in regard to size and appearance of the canes growing in each location. Dead and noticeably immature specimens were, of course, rejected. The sample of twenty canes was carried to the laboratory and reduced to a workable bulk by quartering, the upper fourth of the first cane, the second fourth of the second cane, etc., being reserved for analysis, so that the final sample consisted of twenty pieces of cane, five each from the different quarters. These were then weighed and passed through a small hand mill, by which an extraction of about 70 per cent was obtained. The resulting bagasse was weighed and the juice determined by difference, after which juice and bagasse were analyzed separately and the results calculated to percentages on the entire cane.

Cane analyses, district of Bago.

No.	Remarks.	Average weight per cane.	In cane.		In juice.			
			Su- crose.	Fiber.	Brix.	Su- crose.	Quo- tient of purity.	Reduc- ing sugar.
20	Canes taken at random as they are brought to the mill, hacienda Lumanigub; should yield "No. 1" Sugar.	<i>Kilos.</i>	<i>Per ct.</i>	<i>Per ct.</i>		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
		0.96	16.55	10.05	20.41	19.28	94.45	0.26
21	Plant cane from soil number 14, hacienda San Esteban, Malinao; fifteen months old	0.82	17.19	9.39	21.24	19.64	92.94	0.39
22	Plant cane, twelve months old, from soil number 15, hacienda San Esteban. This field very sparsely grown and canes quite small.	0.66	17.04	10.10	21.14	19.64	92.92	0.40
23	Plant cane, twelve to thirteen months old, from soil number 16, hacienda Alegria; best land in the district. Canes rather slender, but of good size; will yield up to 8 metric tons of "No. 1" sugar per hectare	1.07	16.79	10.43	21.30	19.27	90.40	0.66
24	Plant cane fourteen months old, from soil number 17, hacienda Lumanigub	1.10	17.36	9.48	21.38	19.76	92.45	0.51
25	Plant cane twelve months old, from soil number 18, hacienda Santo Domingo	1.03	16.47	9.96	20.43	18.88	92.41	0.63
26	Plant cane fourteen months old, from best soil number 19, hacienda San Juan del Monte	1.09	16.54	8.95	20.19	18.69	92.62	0.63
28	Plant cane, twelve months old, from hacienda Progreso, soil number 24. Said to yield "No. 1" and "No. 2" sugar	1.24	16.30	10.00	20.88	18.67	89.43	1.22
29	Plant cane, twelve months old, from soil number 25, hacienda Progreso. Canes large, but have fallen down badly; said to yield "No. 3" to "corriente" sugar	1.40	13.34	8.48	17.58	14.88	84.63	1.22
31	Plant cane from poor soil, number 27, hacienda Consorcio. Canes twelve months old	0.58	16.47	11.18	20.34	19.26	94.71	0.29
	Average	1.00	16.41	9.80	20.49	18.80	91.70	0.62

A feature of the canes from Bago, which will at once be noted from the foregoing analyses, is their remarkable uniformity of composition, especially those from the lower portion of the district. Among eight different samples from different fields and plantations, the greatest difference between highest and lowest sugar content of the cane is less than 1 per cent. Even number 31, from the very poor soil along the Bacolod road, varies from the others only in its larger percentage of fiber, this undoubtedly being brought about by the dry and arid nature of the soil in which it grows. The uniformity of cane here is caused largely by the fact that the soil is not sufficiently fertile to make ratooning of common occurrence, so that practically all is cane planted from

tops, and there is sufficient land uncultivated to allow each field to become fully ripe before cutting, even if it has to lie over the next year without planting. Soils poorer than the average seem to exert an influence solely on the size of canes produced and the thickness of their growth. Examples of this are numbers 22 and 31, grown in soils numbers 15 and 27, respectively. In addition to being not much over half the average weight of the majority, these canes are much fewer in number to the hectare.

The newer, richer soils of the upper Bago district tend to produce a cane of wider variation in composition, as is shown by numbers 28 and 29, it being on the whole rather poorer in sucrose, although the cane itself is considerably larger. The reducing sugar content of the two samples analyzed, coming from the upper district, was about twice that found lower down, this being in part due to the fact that these larger canes might not have had time to ripen fully, although it was stated that they were twelve months old, and, in a lesser degree, to bad roads and poor means of transportation causing a delay of a day and a half between cutting and analyzing the cane. For the latter reason it was not found practicable in the limited time at my disposal to investigate more thoroughly the upper Bago region.

Taken on an average, canes from the district of Bago are characterized by a high percentage of sucrose, relatively much less fiber than are those lower down, and an extremely high purity. Of course, the purity is somewhat exaggerated by the fact that the juice was expressed by a mill of comparatively little power. The residual juice left in the cane might run from 3 to 4 per cent lower in purity. Such cane as this would be considered almost ideal for a modern mill. The soft fiber, small in amount, would allow the expression of the greater part of the juice in the crusher and first mill, while, because of the richness and high purity of the juice itself, it would allow of dilution to such an extent that enough maceration water could be used so that only a trifling amount of sugar should be lost in the bagasse from the third mill. In fact, I very much doubt if there are to be found, in any part of the world, canes more admirably adapted for yielding good results in milling. From a purely agricultural standpoint such canes are somewhat less desirable. Grown under normal conditions they are by no means large, and, when planted in new or extra fertile soil, have a tendency, because of their low-fiber content, to fall down badly and ripen slowly or not at all. They are also quite sensitive to drought, lack of moisture affecting their size more than their composition. Because of their tenderness and extreme richness they might also, theoretically at least, fall an easy prey to diseases and to insect pests, although of these, fortunately, we thus far have little record.

The general characteristics of high sucrose, low fiber, and high purity are by no means confined to canes growing in the Bago district, but, as will be shown in subsequent analyses, hold good to a greater or less extent over the entire island, those from Bago being somewhat

more uniform in these qualities than is the case in some other districts, but varying little from the general average.

PONTEVEDRA-LA CARLOTA.

This district, the second largest in the island, which includes all the territory lying around and between the above-named municipalities and extending south and east up to and including the barrio of La Castellana, is situated just south of Bago and separated from it along the coast by the municipality of Valladolid, further inland by a section of low rice land along the San Enrique River. La Carlota itself, the principal town in the district, is 10 kilometers inland and lies to the north of most of the haciendas. Transportation for passengers and mail from Iloilo is effected by way of Pulupandan, with which town a steamship service thrice a week is maintained, the voyage requiring only four or five hours. From Pulupandan south along the coast through Valladolid to San Enrique a fairly good road is encountered, but from there inland to La Carlota it can hardly be called a road, except in the dry season.⁴ The whole journey by quilez, drawn by a bull, from Pulupandan to La Carlota, a distance of about 25 kilometers, consumes from five to six hours, and costs, according to the nationality of the passenger, from 5 to 10 pesos.

The sugar from this district is shipped by lorchas to Iloilo, either from the landing in the San Enrique River or from that of Pontevedra, 4 kilometers south, at the mouth of the Candaguit River. From the latter point an animal-power tramway runs directly inland for a distance of 8 kilometers to the haciendas Carmen and Carmen Chica, receiving sugar not only from these two but from many others in the southern part of the district as far as La Castellana. A similar tramway, from the landing at San Enrique through the haciendas Caridad, Candaguit, and Fé to the town of La Carlota, transports sugar and freight for the populations lying more to the northward.

Topographically, the district of Pontevedra-La Carlota is somewhat similar to that of Bago, being quite narrow near the coast and gradually spreading out into a triangular-shaped section extending 20 kilometers inland to the foothills, where it is about as broad as it is long. However, there is here no navigable river as in Bago. No cane is grown at the present time directly along the coast. A strip of from 3 to 4 kilometers here, which is now chiefly marsh land, was formerly planted much nearer to the sea, but cultivation has gradually been driven back by the increasing inroads of salt water. It is quite possible that much of this abandoned land might be reclaimed by an efficient system of drainage.

⁴ Such was the condition in 1908-9. Since that time much work has been done on the roads of this district, and they have been so improved that it is stated that a regular automobile service has been inaugurated between Pulupandan and La Carlota.

Farther to the inland, for some 10 kilometers, the country is fairly level and here are to be found the greater number of the haciendas. East of the town of La Carlota the country becomes more rolling in character, and is so much broken by hills and small streams that only a very small proportion of the part farthest to the interior of the district is suitable for cultivation.

Area and production of the Pontercedra La Carlota district (1908).

	Amount.	
	<i>Hectares.</i>	<i>Per cent.</i>
Number of growers, 47.		
Area of growers' land planted in sugar cane	2,737	27.5
Area of growers' land suited to cane culture but not planted	6,003	60.3
Other land suited to cane culture but not planted	1,220	12.2
Total sugar land	9,960	
Average amount of sugar land in hectares owned by each grower:		
Planted	58.2	
Unplanted	127.7	
Total	185.9	
	<i>Piculs.</i>	<i>Metric tons.</i>
Average amount of sugar produced by each grower.....	4,045	255.8
Average amount of sugar produced per hectare planted ..	69.5	4.39
Total sugar produced	190,098	12,024

In point of production and total area of available sugar land this district is second only to Silay and far surpasses the latter in yield per hectare. In this point, indeed, La Carlota gives better results than the majority of other sections of Negros, the average yield of 69.5 piculs per hectare of land planted being very nearly what might be expected from fairly good sugar soil on any well-managed plantation. The larger yield in this locality may be attributed partially to the soil, which is decidedly richer here than in either Bago or Silay, and also largely to the fact that in La Carlota the haciendas are, as a rule, of greater extent and less handicapped by lack of capital, a number of them being owned or financed by business houses of Iloilo. Moreover, of the total sugar land available a less percentage is reported as actually planted than in any other district, a greater proportion of the yearly crop thus coming from fresh land, and this not on account of poor soil, but more probably because of inadequate milling facilities to take care of a larger crop. Some ratoon cane is grown here, more particularly in the interior, where, on new soils, the first planting is said to yield watery cane and a poor quality of sugar, but the great majority of the haciendas must replant each year.

Back in the foothills at the base of Mount Canlaon, 10 kilometers from La Carlota, lies the so-called "Granja Modelo" or model farm, established for experimental purposes by the Spanish Government, containing 80 hectares of good sugar land. Much benefit to the sugar

industry of the island might have resulted from this station, as it is said to have been at one time very well equipped for experimental work, but during the late war it suffered so severely at the hands of zealous but unscientific *insurrectos* that it has never since recovered.

Following are analyses of soils which represent fairly well all the land lying between La Granja and Hacienda Carmen:

Soil analyses, district of Pontecruda-La Carlota.

Soil No.	Nature of soil.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Volatile matter.	Remarks.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
1	Surface	96.4	0.27	0.29	0.78	0.39	0.23	0.19	11.32	La Granja Experiment Station. Samples taken from a cane field in the west part of the hacienda. Subsoil from a depth of 25 centimeters down to 50 centimeters; at 75 centimeters, much gravel.
1A	Subsoil	98.8	.29	.17	.62	.61	.20	.10	10.22	
2	Surface	86.7	.12	.39	1.95	.66	.35	.34	12.70	La Granja. Taken from an abandoned cane field said to be poor soil.
2A	Subsoil	87.9	.12	.39	2.21	.68	.30	.28	11.60	
3	Surface	83.6	.18	.22	.80	.52	.17	.19	11.41	La Granja. A good cane soil. Second and third year ratoons growing here. Subsoil is a mixture of clay and sand with some gravel.
3A	Subsoil	82.2	.17	.23	.84	.26	.15	.10	10.29	
4	Surface	87.7	.18	.34	1.64	.55	.40	.30	11.24	La Granja, experimental plot. Cane is said to grow very large here, but poor in sugar. Said to have been fertilized in past years, but to what extent is not known.
4A	Subsoil	88.2	.15	.40	1.77	.74	.29	.19	9.84	
5	Surface	96.5	.13	.13	.51	.23	.15	.13	9.65	Hacienda Carmen Chica. Said to be a very good soil, yielding Nos. 1 and 2 sugar. Subsoil a mixture of white and red clay; at 65 centimeters, gravel.
5A	Subsoil	93.4	.13	.15	.49	.28	.12	.08	9.40	
6	Surface	95.7	.10	.16	.52	.18	.07	.09	7.88	Hacienda Carmen Chica. Best cane land ("tierra baja"). A selected sample from same field as number 5. Subsoil white clay mixed with much of the black surface soil and some sand.
6A	Subsoil	90.2	.11	.28	1.06	.12	.08	.05	8.16	
7	Surface	91.8	.09	.12	.55	.17	.09	.14	10.27	Hacienda Carmen Chica. Called poor soil ("abo abo"). Surface soil from 15 to 30 centimeters deep; subsoil clay and sand; at 50 centimeters, much sand (and water in some parts).
7A	Subsoil	87.5	.10	.19	.64	.09	.10	.08	8.50	
8	Surface	98.1	.10	.08	.52	.11	.06	.12	8.99	Hacienda Carmen. Good soil yielding No. 1 sugar. Surface about 15 centimeters deep; subsoil white clay and sand; strike a layer of sand at 60 centimeters.
8A	Subsoil	98.9	.15	.27	.53	.23	.06	.08	11.50	
9	Surface	96.4	.18	.24	.67	.22	.19	.23	12.20	Hacienda Carmen. When fertilized, yields very large crop but not very pure juice. Two years ago this field was not planted, but used as a pasture for sheep and carabaos. Surface soil black loam; subsoil contains much fine yellow sand; at 80 centimeters, all sand.
9A	Subsoil	95.1	.17	.19	.68	.17	.11	.12	8.69	

Soil analyses, district of Pontevedra-La Carlota (Continued).

Soil No.	Nature of soil.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Vola tile mater.	Remarks.
		Perct.	Perct.	Perct.	Perct.	Perct.	Perct.	Perct.	Perct.	
10	Surface	95.1	0.15	0.17	0.67	0.15	0.20	0.14	9.89	Hacienda Esperanza. Good soil, said to yield No. 2 sugar. Subsoil red clay and sand.
10 A	Subsoil	94.2	.13	.21	.69	.17	.15	.08	10.00	
11	Surface	94.5	.06	.05	.24	.31	.09	.12	13.61	Hacienda Esperanza. Poor soil, producing only "corriente" sugar. Subsoil at 30 to 35 centimeters is a mixture of clay and yellow sand; below 1 meter, slate-colored sand and gravel.
11 A	Subsoil	93.1	.06	.05	.18	.29	.03	.08	13.18	
12	Surface	93.8	.16	.33	1.08	.32	.20	.15	7.26	Hacienda Najalin. Best land, said to yield about 90 picus (6.26 metric tons) per hectare of No. 3 sugar. Surface soil from 10 to 20 centimeters deep; subsoil mostly yellow sand; at 30 to 40 centimeters, gravel.
12 A	Subsoil	91.7	.15	.35	1.42	.33	.14	.12	7.90	
13	Surface	93.0	.06	.07	.33	.18	.05	.11	12.39	Hacienda Najalin, higher ground on hillside. Surface soil goes down to about 25 centimeters, below that is red clay to a depth of 5 meters; not as good soil as number 12.
13 A	Subsoil	88.7	.08	.03	.25	.13	.04	.10	11.92	

Soil No.	Nature of soil.	Detritus on 1-mm. screen.		Mechanical analyses of samples (5 grams) of material, district of Pontevedra-La Carlota, passing a 1-millimeter screen. Samples as prepared for chemical analysis.						
		1 mm., gravel.	1.0-0.5 mm., coarse sand.	0.5-0.25 mm., medium sand.	0.25-0.10 mm., fine sand.	0.10-0.05 mm., very fine sand.	0.05-0.005 mm., silt.	>0.005 mm., clay.	Total.	
3	Surface	16.4	3.84	10.64	10.40	12.50	32.96	29.70	100.04	
3 A	Subsoil	17.8	3.50	13.36	15.92	12.32	28.48	26.74	100.32	
4	Surface	12.3	7.52	15.62	14.60	13.96	34.18	14.52	100.40	
4 A	Subsoil	41.8	11.46	25.84	18.08	10.32	25.14	9.52	100.36	
6	Surface	4.3	3.38	11.52	12.27	14.83	37.97	18.86	99.83	
6 A	Subsoil	9.8	3.68	8.48	11.96	15.02	40.68	20.16	99.98	
7	Surface	8.2	2.10	11.61	14.37	13.35	35.09	23.41	99.89	
7 A	Subsoil	12.5	4.60	15.04	14.54	9.16	27.24	29.78	100.36	
8	Surface	1.9	1.33	6.03	9.31	13.11	43.63	26.31	99.72	
8 A	Subsoil	1.1	2.50	3.34	7.90	9.62	45.54	31.44	100.34	
9	Surface	3.6	2.18	11.04	17.62	16.22	32.22	20.94	100.22	
9 A	Subsoil	4.9	3.00	15.90	19.30	14.20	31.50	16.48	100.38	
10	Surface	4.9	2.66	9.86	9.94	12.08	38.46	27.68	100.68	
10 A	Subsoil	5.8	2.48	5.76	9.40	12.72	45.64	24.52	100.52	
11	Surface	5.5	2.66	7.56	9.82	10.52	27.26	42.32	100.14	
11 A	Subsoil	6.9	1.10	4.32	7.20	8.82	31.10	47.64	100.18	
12	Surface	6.2	3.18	12.96	19.08	17.30	31.16	16.50	100.18	
12 A	Subsoil	8.3	5.78	20.52	18.46	12.54	25.78	16.20	99.28	
13	Surface	7.0	1.44	6.48	9.21	11.00	33.63	38.10	99.86	
13 A	Subsoil	11.3	0.78	5.96	7.68	8.26	33.20	44.46	100.34	

These soils average:

Chemical composition.

Nature of soil.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Volatile matter.
	Per cent.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per cent.
Surface -----	93.03	0.14	0.20	0.79	0.31	0.17	0.17	10.68
Subsoil -----	89.60	0.14	0.22	0.88	0.32	0.14	0.11	10.09

Physical composition.

Nature of soil.	>1 mm., gravel.	1.0-0.5 mm., coarse sand.	0.5-0.25 mm., medium sand.	0.25-0.10 mm., fine sand.	0.10-0.05 mm., very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.	Total.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Surface -----	7.0	3.03	10.33	12.66	13.49	34.66	25.93	100.10
Subsoil -----	12.0	3.89	11.85	13.04	11.30	33.43	26.69	100.21

This seems to be the transition point between the "poor" and the "good" soils of Negros. It is probably the best section of the island where plant cane only is chiefly cultivated, and, analytically considered, would be classed as fairly good sugar land in almost any part of the world. The average composition of these soils is raised somewhat by the inclusion in the table of the four samples from La Granja, which are exceptionally fertile, especially as regards phosphoric acid and nitrogen, and these, possibly, should have been excluded, as, according to the native foreman of the place, who has been there since Spanish times, they have, in former years, received much fertilizer. However, the quantity of fertilizer which is ordinarily used on a field in this country should hardly affect its chemical composition to any serious degree.

The local valuation of soils in this district, quoted under "Remarks," is given for what it is worth. It may be of some value taken in connection with the analyses of canes from the same soils. The standard of what constitutes a "good" soil varies much. In the poorer localities, where all cane produced is, as a rule, rich in sucrose, the best soil is that which yields the largest tonnage of cane; whereas planters from newer, more fertile lands, owing to their absolute dependence on the richness and purity of the cane juice for the quality of their sugar, often consider the best soil to be that which yields cane highest in sucrose, even though the total amount of sugar obtained per hectare be rather small. On no other basis, for instance, could it be understood why an especially rich soil, such as number 2, should be considered "poor"

Numbers 5 to 9, taken from the central portion of the district, represent more fairly the class of land from which the greater majority of all the sugar is produced. Number 6 is a selected sample, taken from what is considered to be the best part of the same field of which number 5 shows the average composition. This portion, chemically, is slightly inferior in every respect, with the exception of the percentage of lime in its subsoil. This may possibly render it more easily cultivable and in a measure account for its apparent superiority. Number 7, a

"poor" soil from the same hacienda as numbers 5 and 6, does not betray marked signs of poverty except in its being much coarser, having a sandier texture, only 77.5 per cent of its sub-soil being fine enough to pass a 1-millimeter sieve. Numbers 8 and 9 are two distinct types of soil from the hacienda Carmen, the former, a fairly heavy clay, being considered the better, since the latter, a very sandy loam, though yielding as a rule heavier crops, does not produce as good a quality of sugar. Trusting to chemical analysis alone, number 9 would be considered much superior. The mechanical analyses of these soils show their marked difference, number 8 containing much less sand and more silt and clay than number 9.

In the case of numbers 10 and 12, stated to be "good" soils, as opposed to numbers 11 and 13, "poorer" fields in the same haciendas, analyses agree very nicely with judgment of these lands, based on the practical experience of the planters, numbers 10 and 12 being markedly richer in every element of fertility, and especially so in potash and lime. Physically they contain more very fine sand and silt, and less clay, than numbers 11 and 13.

Following are some analyses of cane grown in this district:

Cane analyses, district of Ponterredra-La Carlota.

No.	Remarks.	Average weight per cane.	In cane.		In juice.			
			Su- crosc.	Fiber.	Brix.	Su- crosc.	Quo- tient of purity.	Reduc- ing sugar.
1	Selected at random from the mill, hacienda Carmen Chica; said to be of average size for this estate and to yield No. 2 sugar	<i>Kilos.</i>	<i>Per ct.</i>	<i>Per ct.</i>		<i>Per ct.</i>		<i>Per ct.</i>
		1.23	14.43	9.71	18.00	16.47	91.47	0.56
6	Plant cane, eleven and one-half months old, grown in the experimental plot of the Bureau of Agriculture Experiment Station at La Granja. Soil number 4	1.46	10.80	9.08	16.16	12.27	75.93	2.26
10	Soil number 5	1.13	13.66	8.57	17.31	15.31	88.53	1.10
12	Soil number 6; yields No. 1 sugar	0.85	16.72	10.36	20.40	18.88	92.53	0.51
13	Plant cane from a field considered to be poor soil, hacienda Carmen Chica. Soil number 7; said to yield No. 3 sugar	1.20	16.12	9.45	19.55	18.24	93.28	0.50
14	Plant cane from good soil, number 8; said to yield No. 1 sugar. Hacienda Carmen	1.18	16.17	10.84	20.05	18.42	91.85	0.60
15	Plant cane from soil number 9, hacienda Carmen, a field fertilized with manure two years previously; said to yield No. 3 sugar	0.93	13.04	8.95	16.76	14.51	86.56	0.89
16	Plant cane, twelve months old, from soil number 10, hacienda Esperanza; said to yield No. 2 sugar	1.22	11.65	8.13	15.77	12.76	80.87	1.45
17	Plant cane, fourteen months old, from soil number 11, hacienda Esperanza. Soil considered very poor for cane, as it yields only "corriente" sugar	0.96	14.22	9.74	17.99	15.97	88.78	1.09
18	Plant cane, twelve months old, from soil number 12, hacienda Najalin. Said to yield No. 3 sugar, which is considered good for this vicinity	1.16	13.57	8.05	17.61	15.14	87.96	1.26
19	Plant cane, fifteen months old, from soil number 13, hacienda Najalin. This field is now being cut and is yielding "humedo" sugar	1.18	13.74	9.39	17.38	15.66	90.12	0.62
	Average	1.14	14.01	9.30	17.91	15.79	87.99	0.99

These canes average lower in sucrose and purity, but are at the same time decidedly larger than those examined in any other district. The high glucose and low fiber of some of them might lead to the belief that they had been cut too soon, but such could hardly have been the case, as they were practically all at least twelve months old, and, as a rule, were taken from fields which were at the time being cut for grinding. Without doubt the time of year had some influence in this respect, however, as La Carlota was the first district visited, and the above analyses were made during the months of January and February, rather early in the grinding season, the average throughout the year would probably result a little better. Nos. 6, 18, and 19 are more typical of the higher lands, while the other samples represent the central and lower portion of the district.

Number 6, taken from a small experimental plot at La Granja, was analyzed more for purpose of comparison with other varieties of cane growing in the same field than as illustrating results ordinarily obtained here. These other varieties of cane will be discussed in a separate paragraph. Numbers 10 and 12 are from the soils numbered 5 and 6, respectively, and, coming as they do from the same field, certainly indicate a marked difference due to variation in the quality of the soil; number 12, from the so-called "best" portion of the field, in reality being much better from the standpoint of the local sugar boiler, as its juice is decidedly purer and richer in sucrose, but, taking into consideration the increased weight of number 10, there is really very little choice between the two in point of available sugar.

Numbers 14 and 15 illustrate the difference in quality of cane grown in clay and in a sandy soil, it being the consensus of opinion among planters in general that under normal conditions the former produces cane of superior quality, but rather small in size, while that yielded by the latter is inclined to be poorer in sucrose, although if given an abundant supply of water it often attains a luxuriant growth. In this particular instance the cane from the sandy soil is not only poorer in sucrose, but is smaller as well, the latter feature being an exception to the general rule.

In numbers 16 and 17 we have another instance of a rich soil producing a larger cane, but one comparatively low in sucrose and purity, while a neighboring field of much less fertility yields a richer, although smaller, crop. The physical difference in the soils from which these canes were taken, as stated above, undoubtedly does its share toward changing the composition of the cane.

In numbers 17 and 18, practically no difference can be detected between cane grown in a rich and in a decidedly poorer soil.

BINALBAGAN-ISABELA.

Theoretically, this is contiguous to the Pontevedra district, and may be reached from there by a trail passing over the foothills and south through La Castellana, from which place the town of Isabela is distant in an air line only about 12 kilometers. Practically, owing to poor roads and lack of transportation facilities, considerable time and expense is saved by returning to Iloilo for a fresh start, and from there proceeding by lorchas directly to the town of Binalbagan, the sail down from Iloilo requiring from eight to twelve hours, during the northeast

monsoon. The return trip, against the wind, may take anywhere from twenty-four hours to a week. The town of Binalbagan is situated near the mouth of a river of the same name, 25 kilometers directly south of Pontevedra. Owing to the shallowness of this river, the lorchas landings are all located within a short distance of its mouth, and all sugar from the district must be brought to this point for shipment to Iloilo, either in bull carts or down the river in small barges of a few tons' capacity. The best sugar lands lie at a distance of from one-half to 2 kilometers on either side of the Binalbagan River, extending thus for 20 kilometers inland to the town of Isabela, up to which place the soil presents the usual characteristics of alluvial ground in Negros, being quite sandy near the river bank, but within a kilometer or so resolving itself into a more or less heavy, wet clay, which, because of lack of drainage, is given over chiefly to the cultivation of rice. From Isabela the cane fields spread out north and south for 5 or 6 kilometers, and to an equal distance back into the mountains, but here they are more broken up by hills and more varied in their character. The same conditions concerning transportation in this district prevail as in the majority of other parts of the island: "In dry weather, all roads are good; when it rains, one stays at home."

Area and production of the Binalbagan Isabela district (1908).

	Amount.	
	Hectares.	Per cent.
Number of growers, 43.		
Area of growers' land planted in sugar cane	2,957	40.4
Area of growers' land suited to cane culture but not planted	2,868	39.1
Other land suited to cane culture but not planted	1,500	20.5
Total sugar land	7,325	
Average amount of sugar land in hectares owned by each grower:		
Planted	68.8	
Unplanted	66.7	
Total	135.5	
	Piculs.	Metric tons.
Average amount of sugar produced by each grower	2,472	156.4
Average amount of sugar produced per hectare planted	36.0	2.27
Total sugar produced	106,308	6,724

Although this is one of the richest localities in Negros, it will be noted that the production per hectare is one of the lowest, due largely to the fact that practically all the lands here allow of the growing of ratoon canes, which system, because of the saving in expense, as it is not necessary to replant, is often carried to an extreme, resulting in very poor crops. From 15 to 30 per cent only of all the sugar produced in this region is from plant cane. The average yield for the whole district is also much reduced by the inclusion of the lower or

Binalbagan portion. Nearly all the land here is owned by one large estate, which, apparently lacking the necessary capital properly to cultivate it, either allows it to lie idle or in uncultivated ratoons of long standing, or rents it out in small parcels to native planters. The average yield of land actually in cane in the municipality of Binalbagan is only 1.35 metric tons per hectare, whereas the somewhat better cultivated, but no richer, soils of Isabela produce a little over double this amount. The average amount of land owned by each planter is just about the same as that in other parts of the island, although decidedly more is reported as under cultivation, this latter circumstance being also due to the greater preponderance of ratoon cane in this region.

Below are given analyses of soils throughout this district. As no cane analyses were made here, the figures as to quality and quantity of sugar produced, etc., refer to statements made by individual planters.

Soil analyses, district of Binalbagan-Isabela.

Soil No.	Nature of soil.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Volatile matter.	Remarks.
		<i>Per ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	
38	Surface	100.0	0.15	0.16	1.38	1.01	0.23	0.13	9.87	Hacienda San Jose. "Tierra mestiza" along bank of Binalbagan River. Land close to river is considered best, as farther away it is too low and better suited for rice than cane. This soil covered by floods each year; said to yield up to 200 piculs (12.65 metric tons) Nos. 1 and 2 sugar per hectare. Surface soil light loam; subsoil at 30 centimeters, black clay mixed with yellow sand, growing somewhat sandier with increase in depth.
38 A	Subsoil	99.9	.13	.14	1.37	.91	.19	.10	9.40	
39	Surface	99.9	.15	.13	1.57	.75	.21	.13	9.47	Hacienda Santa Irene, Binalbagan. Field about 500 meters from rivers, clay loam. Manager of plantation has no idea of amount of sugar produced. Subsoil, at 25 centimeters, black clay mixed with fine yellow sand.
39 A	Subsoil	100.0	.13	.10	1.20	.90	.21	.10	10.00	
40	Surface	98.5	.18	.21	1.67	1.09	.18	.06	5.65	Hacienda San Jose, Caman Caman, Isabela. Sandy loam, near a small river back toward the mountains; said to give large yield of cane, but poor quality. Subsoil at about 15 centimeters, nearly all sand down to 80 centimeters, where some black clay is touched.
40 A	Subsoil	99.0	.15	.28	1.70	1.00	.15	.03	5.68	
41	Surface	99.9	.16	.13	.93	.90	.20	.13	8.54	Hacienda San Jose, Caman Caman, Isabela. Land a little farther from river; not so sandy as number 40; yields No. 1 sugar, but not so much as number 40. Subsoil at 30 centimeters, black clay mixed with some sand.
41 A	Subsoil	99.8	.15	.11	.90	.72	.14	.09	9.24	

Soil analyses, district of Binalbayan-Isabela—Continued.

Soil No.	Nature of soil.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Volatile matter.	Remarks.
		<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	
42	Surface	99.7	0.11	0.05	0.72	0.18	0.08	0.10	80	Hacienda Constancia, Isabela. "Tierra mestiza." Considered a very good soil for plant cane, but not for ratoons: 20 hectares have averaged 145 piculs (918 metric tons) sugar per hectare from plant cane. Can produce two years of ratoons, but not more. Subsoil at 25 centimeters, black clay and some sand, becoming sandier as deeper; at 50 centimeters, a little gravel and white clay.
42 A	Subsoil	99.3	.14	.04	.70	.77	.08	.09	9.67	
43	Surface	100.0	.21	.37	2.23	.74	.25	.17	9.39	Hacienda Nalipay, Isabela. Black loam, not reached by floods, said to yield 100 piculs (6.33 metric tons) sugar per hectare of plant cane, produces four to five ratoon crops. Subsoil, practically no difference from surface at least down to 80 centimeters, sample "subsoil" was taken from 60 to 80 centimeters.
43 A	Subsoil	100.0	.15	.28	1.97	.94	.23	.14	10.91	
44	Surface	100.0	.10	.23	1.67	.91	.16	.15	11.82	Hacienda Nalipay. "Tierra baja" black clay, said to be good for plant canes, but only yields about two years of ratoons. Subsoil, black clay at 20 centimeters, getting stiffer and wetter with increased depth; at 80 centimeters, still black clay.
44 A	Subsoil	100.0	.09	.14	1.61	.89	.22	.10	11.92	
45	Surface	99.8	.10	.24	2.05	.95	.16	.13	11.59	Hacienda Antolanga, Isabela. Black clay, considered the poorest land in the estate. Subsoil at 25 centimeters, stiff black clay. This hacienda is one of the farthest back toward the mountains of the Isabela district.
45 A	Subsoil	99.9	.08	.23	2.25	1.06	.07	.08	9.94	
47	Surface	99.8	.21	.17	1.34	.82	.26	.17	10.40	Hacienda Progreso, Isabela. Black loam, 200 meters from river. Subsoil begins about 35 centimeters; clay and some sand.
47 A	Subsoil	99.8	.18	.11	1.25	.94	.14	.13	11.01	
48	Surface	99.9	.11	.07	1.23	.86	.22	.16	12.07	Hacienda Tagum Tagum, Isabela. Clay loam washed by yearly floods; called poor land; will yield 100 piculs (6.33 metric tons) of No. 1 sugar per hectare from plant cane if allowed to rest a year, but only 50 to 60 piculs (about 3.5 metric tons) from first ratoon; after that does not yield more unless allowed to rest again. Subsoil at 25 to 30 centimeters, stiff black clay.
48 A	Subsoil	99.7	.11	.06	1.33	.92	.09	.09	10.87	

At first glance, this appears but very little better than the average soil in the neighboring district of Pontevedra-La Carlota, and one is somewhat at a loss to explain why so much more ratoon cane is grown here, but, leaving out of account the fresher, less-cultivated hill soils of the latter, where, indeed, much ratooning is done, the Binalbagan-Isabela district will be found uniformly decidedly richer in composition. Many of the fields along the Binalbagan River are overflowed during each rainy season, and thus have their fertility renewed by deposits of silt and clay brought down from the mountains. The relatively larger amount of lime in these soils very probably is an additional factor tending toward increased fertility. It is a curious fact, to be noted generally throughout the Island of Negros, that the better a soil the more lime, as a rule, it will be found to contain, and even in those sections which are, on the whole, excessively well supplied with this element, fields which have the reputation of producing exceptionally good crops of cane are often found to run higher in lime than their poorer neighbors. It is very difficult to draw conclusions of any kind as to the respective value of soils merely from growers' estimates of their yield, many of these being purely impromptu guesswork, since cane is never weighed in the Philippines and most fields are measured by the number of "tops" planted in them; nevertheless, the relative merits of different fields in his own hacienda should be fairly well known by each planter, and any consistent analytic differences between so-called "good" and "poor" soils are at least worthy of note. Of all the soils examined in this district, none may really be termed "poor" in the same sense as some of the "exhausted" soils of Silay and Bago. All of them are perfectly capable of producing good crops of cane when properly cultivated, although some show a greater capacity for ratooning than others. Theoretically, and this is borne out in Negros at least by practical experience, a soil to produce good ratoon crops must either contain a relatively larger amount of plant food than one which is fit for plant cane only, or, by some means—be it physical, mechanical, or biological—must be enabled more readily to supply the young sprout with its necessary nourishment; since, when cane is planted new every year, the soil is first thoroughly mixed and broken up by plowing and harrowing, while the ratoon must depend for its growth largely upon that portion of the soil directly around it and untouched by cultural operations. All other conditions being equal, it would seem quite possible that a field yielding heavy crops if planted afresh each year, might be quite unprofitable for ratoons through lack of sufficient excess of any one constituent, while another piece of land in the same locality might produce rather less sugar from the first planting, and yet continue ratooning for many years with only slightly diminished yields.

Such may be the case with the four soils, numbers 42, 44, 45, and 48, which are called "poor," since they do yield many ratoon crops. Analysis shows them to be just about as rich as any of the other soils of the district in every element except potash, in which latter they are uniformly lower, the figures ranging in the surface soils from 0.10 to 0.11 per cent. It will be remembered that in Bago and Silay, whose lands average 0.11 per cent of potash or less, ratoons are very uncommon, and one might be almost justified in making the statement that, under the conditions prevailing in Negros at the present time, a soil which contains less than 0.11 per cent of potash will in all probability not yield profitable ratoon crops, even though it be in other respects very fertile. The converse of this is by no means to be inferred, as a dozen other factors might be just as important or more so than the amount of potash, or, for that matter, of any other element which it contains. Still, it would be interesting to try the effect of a potash fertilizer on some of the non-ratooning soils of this district.

ILOG-CABANCALAN.

The last of the large sugar districts in Occidental Negros lies 20 kilometers south of Binalbagan in the Ilog River valley, and consists of a strip of land about 7 kilometers wide and 25 kilometers long. Transportation between this district and Iloilo is carried on in the same way and requires about the same length of time as from Binalbagan. Freight on sugar to Iloilo is from 20 to 25 centavos per picul (3.16 to 3.95 pesos per metric ton). The Ilog River is navigable by sugar lorchas at high tide as far inland as the hacienda San Isidro, about the center of the district, but, owing to a sand bar at the mouth of the river and shallow places farther up, at least two high tides must be awaited in order to get a boat in or out from this place. It takes about one hour to come down the river in a banca from the town of Cabancalan to the hacienda San Isidro; from there on to the town of Ilog an hour and a half longer; and thence to the mouth of the river from one to two hours, according to the tide. A low mountain range, distant from 5 to 10 kilometers, lies on the right bank, going up. The sugar lands along the left bank are best within 2 or 3 kilometers of the river, then deteriorate into low rice lands for a short distance, and finally merge into the rough, stony country between this point and Jimamaylan. A fairly good wagon road exists on this side between the towns of Ilog and Cabancalan, and a passable trail northward to Suay, Jimamaylan, and Binalbagan. The roads on the right side of the river are limited to those kept up by the individual haciendas.

The sugar lands of this district have been formed by alluvial deposits from the river, which overflows annually, flooding a large proportion of the cane fields, but doing, as a rule, little damage to the growing cane. They are classified locally according to their physical make-up into three main types of soil. "Bombon," a light, very sandy soil, found in high places close along the river banks, is made up of the fine sand and other heavier sediment which first settles as the river overflows its boundaries. It has only a comparatively shallow

covering of vegetable surface soil with a subsoil of extremely fine yellow sand and silt. Cane planted here grows superlatively well in years of plentiful rainfall, but is apt to yield a rather watery, impure juice, and does not stand drought well. With a little irrigation to tide them over dry spells, such lands should produce much better than they do at present.

Adjoining the "bombon" soil and at a somewhat lower level and a few hundred meters from the river is the so-called "tierra mestiza," a black loam, which, as its name indicates, is a "mixture" of very fine sand and silt, with a little clay. The subsoil is likewise very fine sand, silt, and black clay, sometimes well mixed, sometimes in streaks. This is considered the best land for cane growing, as it produces large cane of good quality, has good natural drainage, and yet is not injured by a moderate amount of dry weather.

Farther away, in lower land, where the floods stand at times long enough to deposit the finest silt and clay which they carry, are the "bankil" or heavy clay soils,⁵ which are stated to yield the richest cane, although not as heavy in tonnage as the others. In dry years these lands are reliable producers, but early, excessive rains coming before the young cane has attained a sufficient height often have a very harmful effect, unless the land is divided into small fields by ditches and artificially drained at considerable expense. The heaviest of these "bankil" soils are not much used at present for cane growing because of the difficulty of working them, and are either left uncultivated or used as rice lands.

Area and production of the Ilog Cabanalan district (1908).

	Amount.	
	<i>Hectares.</i>	<i>Per cent.</i>
Number of growers, 22.		
Area of growers' land planted in sugar cane.....	1,632	46.8
Area of growers' land suited to cane culture but not planted.....	857	24.6
Other land suited to cane culture but not planted.....	1,000	28.6
Total sugar land.....	3,489	
Average amount of sugar land in hectares owned by each grower:		
Planted.....	74.2	
Unplanted.....	38.9	
Total.....	113.1	
	<i>Piculs.</i>	<i>Metric tons.</i>
Average amount of sugar produced by each grower.....	5,218	330.0
Average amount of sugar produced per hectare planted.....	70.3	4.45
Total sugar produced.....	111,804	7,261

⁵ Number 32 is a typical "bankil" soil. Compare its mechanical analysis with those of other soils from this district.

Compared with other districts, the Ilog River valley produces much more sugar per hectare of land planted, although three-fourths of this comes from ratoon cane, and the limit of production has by no means been approached. Somewhat less than the average amount of land is here owned by each planter, but he has a much larger proportion of what he owns under cultivation and produces annually over twice as much sugar as the average grower throughout the island. Apparently, only a small percentage of the total land fit for sugar production in this district is unused, but in reality about twice as much as is now considered suitable for cane growing could, by means of an efficient system of subsoil drainage for the heavy "bankil" soils and rice lands, be brought into use.

The following are analyses of typical soils from this locality.

Soil analyses, district of Ilog-Cabancalan.

Soil No.	Nature of soil.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Volatile matter.	Remarks.
		Perct.	Perct.	Perct.	Perct.	Perct.	Perct.	Perct.	Perct.	
29	Surface	99.7	0.21	0.24	2.05	1.15	0.18	0.10	8.32	Hacienda San Isidro, "Tierra mestiza," a mixture of black clay and sandy loam; considered best kind of soil; said to average 150 piculs (9.50 metric tons) of Nos. 2 and 3 sugar per hectare from plant cane; now in first ratoon. This land produces best with considerable rainfall; does not stand drought well. Subsoil much the same as surface, but becomes somewhat sandier as goes deeper; at 80 centimeters, still much clay; below this said to be all fine sand.
29 A	Subsoil	100.0	.19	.22	1.96	1.15	.16	.09	8.14	
30	Surface	99.7	.19	.24	4.66	1.31	.17	.09	8.04	Hacienda San Isidro. Same field as number 29, but closer to the Ilog River and soil much sandier ("tierra bombon"). Yields larger with plant cane, but much cane dies if season is dry; will not yield more than three years of ratoons unless much water; now in first ratoon. Subsoil begins at from 30 to 50 centimeters, nearly all fine yellow sand.
30 A	Subsoil	100.0	.17	.30	4.43	1.32	.21	.07	7.20	
31	Surface	99.9	.24	.18	4.40	1.33	.20	.15	9.04	Hacienda Maria. "Tierra mestiza," a mixture of "bankil" and "bombon." Best land said to yield 120 piculs (7.6 metric tons) sugar per hectare. Surface soil is a clay loam; subsoil beginning at 25 to 30 centimeters, a very sandy loam, nearly pure sand in parts, down to 50 to 60 centimeters, where a layer of clay is again encountered. This soil is flooded by the Ilog River nearly every year.
31 A	Subsoil	99.9	.20	.21	4.28	1.39	.19	.13	8.42	

Soil analysis, district of Ilog-Cabamalan—Continued.

Soil No.	Nature of soil.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Volatile matter.	Remarks
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
32	Surface	99.7	0.20	0.23	3.00	1.43	0.16	0.18	11.21	Hacienda Soladad. "Tierra bunki" or stiff black clay. Subsoil about 30 centimeters, black clay mixed with some sand, becoming sandier as deeper; at 45 centimeters, much sand.
32A	Subsoil	98.4	.17	.29	1.84	1.04	.09	.06	6.15	
33	Surface	99.9	.23	.19	2.02	1.50	.24	.12	8.10	Hacienda San Juan. "Tierra mestiza," said to be very good land, but poorly cultivated owing to lack of labor; said to yield about 70 piculs (4.43 metric tons) of No. 2 sugar per hectare, now in plant cane. Subsoil almost same as surface down to about 40 centimeters; below this a very little sand mixed with much clay.
33A	Subsoil	99.8	.23	.18	2.05	1.42	.19	.09	7.92	
34	Surface	99.9	.20	.22	4.52	1.32	.17	.13	8.82	Hacienda San Juan. Best land; a rather light loam, but not sandy, now in third ratoon; said to yield 100 piculs (6.33 metric tons) or more of No. 3 sugar per hectare. Subsoil from 25 to 30 centimeters down, considerable yellow sand.
34A	Subsoil	99.8	.19	.22	5.46	1.09	.15	.07	6.80	
35	Surface	100.0	.19	.11	4.90	1.64	.22	.18	10.75	Hacienda San Luis. Clay loam, about 200 meters from river. Is flooded every year; now growing fourth ratoon crop. Subsoil much the same as surface, but somewhat stiffer clay.
35A	Subsoil	99.9	.18	.12	4.22	1.89	.17	.13	10.10	
36	Surface	99.9	.20	.15	3.19	1.06	.17	.13	8.14	Hacienda San Lucas. "Tierra bombon," a sandy loam not reached by floods; said to yield 120 piculs sugar (7.60 metric tons) per hectare from plant cane and 90 piculs (5.70 metric tons) from first ratoons. Subsoil at 25 centimeters, mixture of loam and very fine sand, at 40 centimeters, nearly all sand, at 80 centimeters, still pure fine sand, no gravel.
36A	Subsoil	99.9	.16	.18	3.49	1.17	.15	.06	6.56	
37	Surface	96.9	.25	.17	2.85	1.32	.23	.18	7.80	Hacienda San Isidro. Best field, "tierra mestiza," most of field is covered by yearly floods from river. Last year this field (7 hectares) said to have averaged 200 piculs (12.65 metric tons) per hectare of No. 3 sugar from canes planted in October and cut in January (fifteen months old). Soil is a black loam; subsoil at 30 centimeters, black clay mixed with very fine sand or silt in streaks, at 60 centimeters, mostly black clay.
37A	Subsoil	98.0	.19	.19	2.47	1.30	.21	.11	7.70	

Soil No.	Nature of soil.	Detritus on 1-mm. screen.	Mechanical analyses of samples (5 grams) of material, district of Ilog-Cabancalan, passing a 1-mm. screen. Samples as prepared for chemical analysis.						
		1 mm., gravel.	>1.0-0.5 mm., coarse sand.	0.5-0.25 mm., medium sand.	0.25-0.10 mm., fine sand.	0.10-0.05 mm., very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.	Total.
29	Surface	0.3	0.08	1.28	9.96	32.70	44.64	11.42	100.08
29	Subsoil	0.0	0.00	0.26	7.88	31.48	50.48	9.08	99.14
30	Surface	0.3	0.12	1.14	12.78	45.74	33.28	7.12	100.18
30	Subsoil	0.0	0.02	0.80	17.16	35.06	40.18	6.60	99.82
32	Surface	0.3	0.44	3.36	14.76	10.28	46.22	25.18	100.54
32	Subsoil	1.6	0.94	7.70	17.28	9.62	37.60	26.80	99.94
33	Surface	0.1	0.06	0.42	9.90	39.40	38.02	12.84	100.64
33	Subsoil	0.2	0.04	0.20	7.04	32.72	49.96	10.06	100.02
34	Surface	0.1	0.08	2.62	16.80	34.72	38.34	7.70	100.26
34	Subsoil	0.2	0.40	9.00	26.54	21.18	32.78	9.92	99.82
35	Surface	0.0	0.06	0.98	12.22	15.42	52.02	19.24	99.94
35	Subsoil	0.1	0.02	0.38	13.70	12.80	51.32	20.40	99.12
36	Surface	0.1	0.08	1.44	16.44	28.44	43.88	10.14	99.92
36	Subsoil	0.1	0.04	1.74	27.12	30.32	33.72	7.52	100.46

The average of these surfaces and subsoils is as follows:

Chemical composition.

Nature of soil.	Fine earth.	K ₂ O	Na ₂ O.	CaO.	Mgo.	P ₂ O ₅ .	N.	Volatile matter.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Surface	99.51	0.21	0.20	3.51	1.34	0.19	0.13	8.91
Subsoil	99.52	0.19	0.21	3.36	1.31	0.17	0.09	7.67

Physical composition.

Nature of soil.	>1 mm., gravel.	1.0-0.5 mm., coarse sand.	0.5-0.25 mm., medium sand.	0.25-0.10 mm., finesand	0.10-0.05 mm., very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.	Total.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Surface	0.2	0.13	1.61	13.27	29.53	42.27	13.42	100.22
Subsoil	0.3	0.21	2.87	16.67	24.74	42.36	12.91	99.76

The practically uniform composition, chemically, of these soils all along the river valley is probably due to their original formation from the same source—sand, silt, and clay brought down from the mountains by the summer floods. In comparison with the districts thus far examined they are much richer in most of the so-called elements of fertility, being exceptionally so in lime, of which substance a very much

larger percentage is here found than in soils from any other part of Negros. Much of this exists as the carbonate, as is shown by the marked effervescence which takes place on treating almost any of the Ilog soils with acid. Nitrogen, only, appears to be a trifle low, especially in some of the sandy, "bombon" lands, but this is rather to be expected in soils having the physical make-up of these under consideration. It is evident that, as all the land here contains an excess of plant food sufficient for both plant canes and ratoons, without considering the additional nutrient matter supplied each year by the overflowing of the river, differences in productivity and in quality of the cane for the greater part be due to the amount of care taken in cultivation, together with the combined effects of the weather and the physical composition of the soil. According to the quantity of rainfall in a given year, a sandy soil may produce much more cane than a heavy clay, or the reverse, so that only by means of experiments covering many years, together with meteorologic observations during the same period, would it be possible to state which type of soil was really best suited to cane in this vicinity. However, a few cane analyses were made here and are given in the following table:

Cane analyses, district of Ilog-Cabancalan.

No.	Remarks.	Average weight per cane.	In cane.			In juice.		
			Su- crose.	Fiber.	Brix.	Su- crose.	Quo- tient of purity.	Reduc- ing sugar.
32	First ratoon cane from soil number 29, hacienda San Isidro. Canes twelve months old.	Kilos. 0.98	Per ct. 18.37	Per ct. 10.10	22.33	Per ct. 20.98	93.96	Per ct. 0.23
33	First ratoon cane from soil number 30, hacienda San Isidro. Soil is sandier and nearer river than that in which canes number 32 are growing. Canes 12 months old have fallen down worse than number 32.	1.00	15.58	9.35	20.28	17.81	87.84	1.00
34	Plant cane, fourteen to fifteen months old, from soil number 32; a black clay. Hacienda Soledad. Canes slender but fairly long.	0.88	15.87	11.14	20.61	18.66	90.53	0.49
35	Plant cane thirteen months old, from soil number 33, hacienda San Juan. These canes small and stunted in growth on account of lack of cultivation; were attacked by locusts while young.	0.41	17.73	10.02	21.39	20.33	95.06	0.12
36	Thrd ratoon cane from soil number 34, hacienda San Juan.	0.89	15.29	9.72	19.43	17.52	90.14	0.62
37	Hacienda San Luis.	0.63	17.46	9.23	22.03	18.96	90.14	0.82
38	First ratoon cane, eleven months old, from soil number 36, hacienda San Lucas, said to yield about 90 piculs (5.7 metric tons) per hectare.	0.71	18.34	9.15	22.17	20.85	94.06	0.18
	Average.	0.79	16.95	9.81	21.18	19.30	91.67	0.49

Taken collectively, the cane from Ilog is quite similar in composition to that of Bago, a condition hardly to be expected in view of the marked dissimilarity between the soils of the two districts and the fact that the majority of the canes examined in Ilog were ratoons while those from Bago were all from the first planting. Probably these are compensating differences, since both a poor soil and the growing of ratoon crops have an apparent tendency to produce a cane rather smaller and richer than the ordinary. In the case of Ilog, also, the analyses were made during the month of April, at the latter end of the grinding season, after several weeks of dry, hot weather, when all the cane would naturally be somewhat drier and richer than usual, so that in all probability an average of the crop throughout the year in this district would be considerably larger and somewhat poorer in sucrose than the figures quoted. Few of the individual canes in this list vary sufficiently from the average to indicate any distinctions due to the soil in which they are growing.

Numbers 32 and 33 again illustrate the difference often noted between a loam or clay and a sandy soil, although the two fields from which they were taken are adjoining ones and their soils chemically much the same. Number 33, although by no means a poor cane, is still decidedly lower in sucrose and fiber than number 32, the one from the heavier soil,^a while its higher reducing sugar content, 1 per cent, would almost indicate that it was hardly ripe, yet both fields were of the same age. The higher fiber of number 34 was probably brought about by the long time it had remained in the ground, becoming thoroughly mature and dry. Number 35 shows the damage done by locusts in stunting the growth of a cane field, even when they do not entirely destroy it. Number 36, from a light loam with sandy subsoil, is characteristically lower in sucrose, while number 38, from a very similar soil, not only does not show this distinction, but is considerably purer and richer in sucrose than the average.

SAN CARLOS.

The larger of the two important sugar centers on the east coast is situated in the northern part of Negros, directly across the island from La Carlota, on the arbitrary dividing line separating Occidental and Oriental Negros. The town of San Carlos, about the center of this district, possesses a safe, although not very deep, harbor, formed by a projecting point of land and a slight indentation in the coast, at which point a small wharf or lancha landing has been built. Protected by its own coast line from the northeast monsoon, the harbor is quite calm during the grinding season, and is sheltered from the southwest winds of the rainy season by the small island of Refugio, lying

^a According to mechanical analysis, neither of these soils contain a large amount of clay, but the one producing cane, number 32, is decidedly finer in texture than its neighbor.

close by, so that very little trouble is here experienced from rough weather. A channel between Refugio and the mainland is sufficiently deep for vessels of moderate size, which may anchor within a short distance of the wharf. A fairly regular mail and passenger service to Iloilo, 180 kilometers distant by sea, is available once or twice a week, the trip requiring about fourteen hours, while sugar and heavy freight is transported, as in other districts, by lorchas, which are usually towed up against the wind for about half the distance, or until well around the northern end of the island, and then cast loose to sail down with the wind into Iloilo. The customary freight rate here is 25 centavos per picul (3.95 pesos per metric ton).

The sugar plantations of San Carlos lie in a direct line along the coast, extending from the hacienda Santo Tomas in the north to Valle Hermoso in the south, a distance by land of 23 kilometers, by sea a trifle less, and are connected by wagon roads passable in dry weather down as far as the haciendas Santa Cruz and Santo Niño (Mabuni), 5 kilometers south of the town. In passing the next 3 kilometers between Santo Niño and the hacienda Fortuna, the land becomes much more broken and accidental in character, and from this point on to Valle Hermoso there exists only a rocky trail along the coast, from one and one-half to two hours being required to traverse the 5 kilometers between these two places on horseback.

The sugar lands of this side, unlike those of western Negros, do not extend inland to any distance, but are shut off by mountains which are never more than 3 or 4 kilometers from the sea, and thus afford room for only one fairly large estate between the foothills and the coast. All the haciendas of this district, with the exception of Fortuna and Valle Hermoso, the two farthest south, occupy the fairly level strip of land which has the town of San Carlos as its approximate center. These two haciendas, of much larger extent than the others, are made up of a number of separate fields, wherever level ground can be utilized in the valleys between the hills.

No less than eight small streams pass through the district, but none of them are large enough for navigation of any kind, so that the sugar lorchas must anchor close to the coast and have their freight brought out to them in small boats, or, in the town of San Carlos and in the hacienda Fortuna, be loaded directly from small, private wharves.

Area and production of the San Carlos district (1908).

	Amount.	
	<i>Hectares.</i>	<i>Per cent.</i>
Number of growers, 14.		
Area of growers' land planted in sugar cane	2,080	60.4
Area of growers' land suited to cane culture but not planted	866	25.1
Other land suited to cane culture but not planted	500	14.5
Total sugar land	3,446	
Average amount of sugar land in hectares owned by each grower:		
Planted	118.6	
Unplanted	61.9	
Total	210.5	
	<i>Piculs.</i>	<i>Metric tons.</i>
Average amount of sugar produced by each grower	5,450	344.7
Average amount of sugar produced per hectare planted	36.7	2.32
Total sugar produced	76,300	4,826

The average grower of this district owns a larger amount of land, has more of it under cultivation, and produces annually a greater quantity of sugar than elsewhere in Negros, although the average yield of sugar per hectare reported under cultivation is very small, being, in fact, less than half of what even a moderately good field in this locality will ordinarily produce. San Carlos has suffered much of late from drought, due in a great measure to the almost total destruction of the forests and shrubbery in the foothills and mountains lying just back of all the plantations. This has been brought about by nomadic mountain people, who burn off a small patch of land to form a "caingin," which they plant in corn for a year or so, until weeds begin to spring up and a little real work is necessary for further cultivation, when they move on to devastate more forest land farther along. It will probably be many years before San Carlos completely recovers from the evil effects already produced by these "caingins," even if this wanton destruction of timber can be at once stopped, which seems rather doubtful, although some steps are now being taken to keep the practice in check.

The following is a table giving analyses of representative types of soil from this district, together with remarks as to their approximate yield and relative merits according to the local classification.

Soil analyses, district of San Carlos.

Soil No.	Nature of soil.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Volatile matter.	Remarks.
			Perct.	Perct.	Perct.	Perct.	Perct.	Perct.	Perct.	
60	Surface	85.8	0.50	0.22	1.64	1.41	0.12	0.22	8.59	Hacienda San Jose. Field near thesea; said to be very fair land, but has suffered much from drought this season; now in plant cane 1 year old; cane very small; estimated yield 40 to 50 piculs (2.53 to 3.16 metric tons) per hectare. Surface soil very dry and cracked by heat; subsoil at 25 centimeters, a little gravel and coarse sand with brownish-yellow clay in streaks.
60A	Subsoil	79.9	.34	.27	1.84	1.36	.08	.14	7.70	
61	Surface	74.5	.66	.27	1.81	1.42	.13	.21	8.81	Hacienda San Jose. Field near number 60 and similar to it in appearance, but rather more sand and small stones. This field used for first milking test; 1 hectare produces 21.54 metric tons cane and 2.378 metric tons sugar. Cane has suffered much from long-continued dry season.
61A	Subsoil	68.8	.45	.32	1.95	1.92	.12	.18	6.92	
62	Surface	97.5	.57	.22	1.71	1.96	.18	.21	8.36	Hacienda San Jose. High land near river; black loam, a trifle sandy. Good cane land; now in first ratoon crop. Subsoil at 25 centimeters, yellowish clay and a little sand fairly well mixed; a trifle more sand near the river bank.
62A	Subsoil	80	.37	.24	1.93	2.11	.15	.16	8.18	
63	Surface	96.9	.55	.34	2.40	2.41	.22	.22	7.76	Hacienda Providencia. A good cane soil, especially for ratoons. Plant cane said to grow too large and produce poor quality of sugar. Yield about 125 piculs (7.91 metric tons) per hectare from plant cane; part of field near river more or less sandy, while a little higher up somewhat stiffer clay. Subsoil at 30 centimeters, black and yellow clay in streaks with some yellow sand.
63A	Subsoil	97.5	.42	.27	2.50	2.33	.20	.16	7.34	
64	Surface	69.9	.26	.05	1.18	1.23	.08	.31	11.83	Hacienda Providencia. Higher land and near mill. Black clay now in sixth ratoon crop. Estimated will yield 50 to 60 piculs (3.16 to 3.8 metric tons) per hectare. Subsoil at 20 centimeters, white clay with coarse white and yellow sand and pebbles.
64A	Subsoil	77.9	.11	.08	1.01	1.22	.07	.19	10.62	
65	Surface	97.9	.65	.35	2.43	2.24	.21	.29	7.86	Hacienda San Jose. Land near river, considered best soil in the hacienda. Light somewhat sandy loam. Subsoil at 25 to 30 centimeters, clay mixed with sand; at 50 to 60 centimeters, nearly pure yellow sand.
65A	Subsoil	95	.52	.35	2.54	2.24	.21	.07	7.28	

Soil analyses, district of San Carlos—Continued.

Soil No.	Nature of soil.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Volatile matter.	Remarks.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
66	Surface	93.9	0.14	0.09	1.11	1.08	0.10	0.14	9.55	Hacienda Refugio. One of the poorest fields, said to yield about 80 piculs (5.06 metric tons) per hectare of No. 1 sugar from plant cane; now in first ratoon; Black cane. Subsoil at 15 centimeters, white clay mixed with some sand.
66A	Subsoil	96.4	.11	.09	1.13	1.13	.09	.10	9.28	
67	Surface	96.7	.22	.29	2.26	1.49	.18	.10	7.81	Hacienda Refugio. Alluvial soil near river back towards mountains; very good land, said to yield 150 piculs (9.50 metric tons) per hectare of No. 3 sugar from plant cane twelve months old. Soil in appearance much like the sandy loams of Ilog-Cabancalan; subsoil at 20 centimeters, clay with much fine sand.
67A	Subsoil	97.8	.17	.30	2.34	1.63	.11	.07	7.87	
68	Surface	99.8	.36	.21	1.89	1.89	.21	.15	8.88	Hacienda Refugio. Best field, near house, said to yield 160 piculs (10.1 metric tons) sugar per hectare from plant cane and practically the same from ratoons. Surface is a rather light loam; subsoil at 20 to 23 centimeters, brown to black clay with a very little sand.
68A	Subsoil	99.9	.26	.19	1.78	1.69	.23	.10	8.81	
69	Surface	97	.22	.58	1.13	1.18	.14	.12	6.25	Hacienda Refugio. Very poor land near sea; formerly flooded by sea water and probably still influenced by this, as parts of the field are below sea level at high tide. Yield said to be less than 50 piculs (3.6 metric tons) per hectare. Surface soil rather sandy; subsoil at 15 centimeters, very sticky clay.
69A	Subsoil	94	.24	.73	1.32	1.33	.11	.05	5.30	
70	Surface	99.1	.55	.36	3.17	2.30	.14	.14	9.16	Hacienda Fortuna. One of the best fields; said to yield over 100 piculs (6.33 metric tons) per hectare from plant cane. Surface black clay, changing to sandy loam along river bank; subsoil black clay, white clay, and yellow sand, according to distance from river.
70A	Subsoil	99.3	.55	.19	2.83	2.28	.12	.10	8.94	
71	Surface	99.8	.40	.26	5	2.34	.13	.22	9.45	Hacienda Fortuna. Very good cane land; now in second year of ratoons. Surface black clay; subsoil at 20 to 30 centimeters, dark brown clay.
71A	Subsoil	99.8	.46	.14	1.92	2.37	.10	.10	9.21	
72	Surface	99.9	.23	.11	1.56	1	.25	.17	9.55	Hacienda Valle Hermoso. Said to be representative of the soil here. Subsoil at 20 to 30 centimeters, light-colored clay with some sand in places.
72A	Subsoil	99.5	.13	.13	1.65	1.27	.17	.09	7.27	

Soil analyses, district of San Carlos—Continued.

Soil No.	Nature of soil.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Volatile matter.	Remarks.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	
73	Surface	96.7	0.21	0.18	1.19	1.59	0.15	0.14	7.64	Hacienda Valle Hermoso. This soil not liked as well as number 72, as it is a heavier clay and harder to work; this year however it has produced better owing to the exceptionally dry weather. Subsoil at about 25 centimeters fairly stiff white clay.
73A	Subsoil	90.3	.20	.15	1.69	1.19	.10	.09	6.80	
84	Surface	95	.64	.31	1.74	1.37	.14	.12	8.04	Hacienda San Jose. Southern part of the hacienda, near sea, formerly swamp land, yield very poor. Surface soil light loam; subsoil at 20 to 25 centimeters, yellow clay with some sand and gravel.
84A	Subsoil	88.2	.52	.37	1.75	1.88	.10	.07	7.11	
85	Surface	95	.44	.31	1.38	.85	.09	.09	4.71	Hacienda San Jose. Southernmost field, near sea and river; very poor soil, especially in dry weather, at best will not yield more than 80 piculs (5.06 metric tons) per hectare from plant cane or half that amount from first ratoons. Surface soil sandy loam; subsoil at 30 centimeters, coarse sand and small stones.
85A	Subsoil	97.9	.37	.32	1.40	.89	.09	.06	4.61	
86	Surface	99.8	.41	.15	1.53	1.73	.11	.10	9.16	Hacienda San Jose. Field in west of hacienda, near mountains; rather poor land, many large stones. Subsoil at 15 to 25 centimeters, stiff brown clay with some sand and small stones.
86A	Subsoil	95.1	.34	.19	1.58	1.83	.09	.07	9.50	
87	Surface	97.4	.24	.07	1.23	1.16	.09	.18	12.60	Hacienda San Jose. Field south and west of number 87, had not been planted for several years until last season, this year nearly all young canes dead from drought. Surface soil rather light loam, subsoil at 15 to 20 centimeters, stiff light yellow clay, at 70 centimeters, many small stones and reddish clay.
87A	Subsoil	98.8	.20	.05	1.26	1.32	.03	.10	11.52	

Soil No.	Nature of soil.	Detritus on 1-mm. screen.	Mechanical analyses of samples (5 grams) of material, district of San Carlos, passing a 1-mm. screen. Samples as prepared for chemical analysis.						
		>1 mm., gravel.	1.0-0.5 mm., coarse sand.	0.5-0.25 mm., medium sand.	0.25-0.10 mm., fine sand.	0.10-0.05 mm., very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.	Total.
60	Surface	14.2	1.64	5.78	9.06	15.00	16.64	21.80	99.92
60 A	Subsoil	20.1	1.20	4.32	9.16	16.78	50.74	18.00	100.20
61	Surface	25.5	3.96	14.28	16.92	14.26	32.92	17.84	100.18
61 A	Subsoil	36.2	8.02	16.92	15.74	13.70	32.60	12.74	99.72
62	Surface	2.5	1.90	7.32	13.10	17.30	41.08	16.76	100.46
62 A	Subsoil	20.0	5.36	13.70	13.84	11.82	34.92	20.22	99.86
63	Surface	3.1	1.66	7.34	13.60	18.66	44.22	13.64	99.12
63 A	Subsoil	2.5	1.90	7.42	13.84	16.44	48.96	12.10	100.66
64	Surface	30.1	5.65	7.33	8.28	11.41	37.19	30.01	99.87
64 A	Subsoil	22.1	2.62	4.72	5.98	7.52	31.82	47.54	100.20
65	Surface	2.1	1.10	7.16	16.06	18.08	45.28	12.26	99.94
65 A	Subsoil	5.0	1.88	9.14	17.08	19.30	40.10	12.02	99.52
66	Surface	6.1	1.60	5.08	9.94	10.82	43.46	28.52	99.42
66 A	Subsoil	3.6	1.84	6.56	11.02	11.40	40.22	28.58	99.62
67	Surface	3.3	1.71	9.14	19.28	22.28	35.60	11.90	99.94
67 A	Subsoil	2.2	1.64	12.14	24.14	18.58	29.76	13.68	99.94
70	Surface	0.9	0.74	5.64	16.04	21.58	42.18	13.34	99.52
70 A	Subsoil	0.7	0.70	5.08	15.82	20.94	40.18	16.68	99.40
71	Surface	0.2	0.28	2.84	13.40	21.94	48.30	13.02	99.78
71 A	Subsoil	0.2	0.23	2.57	15.83	23.34	43.62	14.54	100.13
73	Surface	3.3	1.76	9.40	12.78	11.92	42.22	22.54	100.62
73 A	Subsoil	9.7	1.76	10.07	12.35	12.72	38.36	25.41	100.67
85	Surface	5.0	8.74	37.90	19.52	7.52	16.38	10.44	100.50
85 A	Subsoil	12.1	7.26	37.82	20.52	7.72	14.80	12.18	100.30
87	Surface	2.6	1.54	3.84	8.43	11.74	36.09	38.87	99.99
87 A	Subsoil	1.2	0.95	2.52	5.42	9.85	34.27	46.97	99.97

The average composition of these soils is as follows:

Chemical composition.

Nature of soil.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Volatile matter.
	Per cent.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Surface	94.03	0.40	0.24	1.94	1.60	0.15	0.17	8.67
Subsoil	91.17	0.32	0.24	1.80	1.67	0.12	0.11	8.01

Physical composition.

Nature of soil.	>1 mm., gravel.	1.0-0.5 mm., coarse sand.	0.5-0.25 mm., medium sand.	0.25-0.10 mm., fine sand.	0.10-0.05 mm., very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.	Total.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Surface.....	7.6	2.49	9.47	13.57	15.58	39.58	19.26	99.94
Subsoil.....	10.4	2.72	10.23	13.90	14.62	36.95	21.59	100.01

Taken as a whole, these may be classed among the most fertile soils of Negros, being exceptionally rich in potash and having a content of lime, phosphoric acid, and nitrogen somewhat above the average. Individually, there is considerable variation, as might be expected in a place which, unlike some of the sugar lands of the west coast, does not lie close along the banks of one large river, but is broken up by many small streams, valleys, and hills, yet, out of the entire series of soils here analyzed, not one could really be called lacking in fertility, as judged by the standards of what constitutes a good cane soil in this island.

Those soils stated by the owners to be relatively poor producers, viz, numbers 66, 85, 86, and 87, while not lacking in potash or lime, are decidedly lower in both phosphoric acid and nitrogen than the majority of fields in this district; still, soils of a similar composition are considered very productive in districts such as Silay or Bago. The unproductiveness of numbers 69 and 84 is undoubtedly occasioned by the deleterious effect of sea water on the roots of the cane, the increased proportion of soda to potash and of magnesia to lime in their subsoils as compared with the surface being pretty good evidence that the lower strata here are at high tide reached by seepage from the ocean. In number 61, also, this effect is indicated, although to a somewhat less marked extent.

On the other hand, the five soils, numbers 63, 65, 68, 70, and 71, are selected as being exceptionally fertile. They are richer than the average in all the chemical elements considered essential to a good cane soil, some of them being especially so as regards lime.

With the exception of the extreme cases just mentioned, differences in productivity must be due to other causes, such as physical characteristics of the soils, time under cultivation, care taken in cultivating and planting, weather conditions, etc. The element of chance, also, is no small factor in sugar growing on many soils. If cane is planted very early, before the rains have stopped, an extra heavy period of rains may ensue late in the season and literally drown out the young cane, especially in heavy, undrained soil, while a late planting may be followed by such excessively dry weather that the plants wither and parch in the ground, and, in sandy soils, are either killed outright or, in heavier ones, have such a poor start that they are unable to stand up before the rains of the next season.

Analyses of sugar cane growing in these soils are given below:

Cane analyses, district of San Carlos.

No.	Remarks.	Average weight per cane.	In cane.		In juice.			
			Su- crose.	Fiber.	Brix.	Su- crose.	Quo- tient of purity.	Reduc- ing sugar
39	Plant cane, twelve months old, from soil number 60, hacienda San Jose; has suffered much from drought	Kilos.	Per ct.	Per ct.		Per ct.		Per ct.
		0.38	17.32	11.02	22.01	20.04	91.03	0.58
42	First ratoon cane, eleven months old, from soil number 61, hacienda San Jose; has suffered much from drought	0.41	18.01	12.51	23.00	21.21	92.15	0.22
43	First ratoon cane, ten months old, from soil number 62, hacienda San Jose	0.41	18.71	11.24	23.49	21.84	92.96	0.27
44	Plant cane, eleven months old, from soil number 63, hacienda Providencia	0.93	15.29	10.64	20.21	17.71	87.62	1.24
45	Sixth ratoon cane, from soil number 64, hacienda Providencia; about ten months old	0.74	16.47	12.61	22.26	19.73	88.65	1.08
46	Plant cane, 10 months old, from soil number 65, hacienda San Jose	1.06	16.76	9.89	21.33	19.26	90.31	0.85
48	Plant cane, twelve months old, from soil number 67, hacienda Refugio	0.80	15.86	11.03	20.84	18.75	89.91	0.97
49	Plant cane, twelve months old, from soil number 70, hacienda Fortuna	1.00	17.00	11.05	21.44	19.86	92.60	0.49
50	Second ratoon cane, twelve months old, from soil number 71, hacienda Fortuna	0.70	17.67	11.22	22.91	20.73	90.51	0.69
51	Hacienda Valle Hermoso. Cane large and many fallen down.	1.13	15.58	10.80	20.96	18.06	86.16	1.35
Average		0.76	16.87	11.20	21.85	19.72	90.19	0.77

These samples differ somewhat from those obtained in other localities, in that they contain more fiber and a juice somewhat more concentrated and richer in sugar. The purity of the juice and its percentage of reducing sugar is about the same as in other districts. It is difficult to account for the increase in fiber found here, as the same variety of cane is grown in San Carlos as in other parts of Negros, except on the theory that the droughts prevalent in this section of the island during the past few years have caused a partial drying out of the cane; this would also explain the greater density and sweetness of the juice.

The first three samples examined have undoubtedly been thus affected, since they have been so stunted in their growth by dry weather as to be only about half the ordinary size. The large amount of alkalis and alkaline earths in these soils may also have a tendency, when concentrated by drought, to check the growth of the cane. Number 45 probably owes its high fiber in a large degree to the length of time it has been allowed to grow without replanting, ratoons of many years' standing apparently showing a tendency toward a harder, more

woody growth. Neither this nor number 44 were quite mature when cut. An excessively dry spell at the time forced many planters to cut fields which were not yet ripe in order to save them from total loss, especially in the case of much cane planted late in the previous year, which had not attained sufficient maturity to enable it to withstand the severe heat and dryness, and was withering in the fields without ever becoming fully ripe. Number 46 was taken from a field similarly affected. Although one of the best soils on the hacienda under normal conditions, it had so badly suffered from drought this year that probably 20 per cent of the cane growing on it was either too green to cut or was dead and partially decayed. The canes taken for analysis, being selected with the view of securing only fairly mature specimens, are apparently very good, although a little young, ten months old, but canes from the same field which were being ground at the mill at this time and could not be so carefully selected, despite instructions which had been given to throw out dead canes as much as possible, yielded a mill juice of the following composition: Brix, 16.75; sucrose, 13.46; purity, 80.34—which of course produced a very poor quality of sugar.

Number 49 is from one of the best fields I have seen in Negros, the cane itself being large and quickly grown, yet erect and of very good quality. Soil number 70, from this field, is very high in potash and lime, but only moderately so in phosphoric acid and nitrogen.

Number 51 is an analysis of cane from a field of very luxuriant growth; in fact, much of it had fallen down so badly that the cane, although thirteen months old, had not been able to ripen as it should, and as a consequence had suffered somewhat in quality. The soil from which it came, although very good, does not on analysis show any extraordinary richness.

BAIS.

About 100 kilometers south of San Carlos, or ten hours' sail by water, lies Bais, the only important sugar district in the Province of Oriental Negros, 43 kilometers north, by the provincial road, from Dumaguete, the capital. The harbor of Bais, the best in Negros, is formed by a fairly deep indentation in the coast line and is well protected from rough weather at all times of the year by two small islands directly at its entrance and by its proximity to the Island of Cebu, which at this point is only 16 kilometers distant. At present it is only available for vessels of comparatively light draft, as it only contains 3 or 4 meters of water at low tide anywhere within a kilometer of the shore. Transportation to Iloilo follows the same route as from San Carlos, but, owing to the longer distance to be carried, freight rates on sugar are somewhat higher, averaging 30 centavos per picul (4.75 pesos per metric ton). Some lorchas load at a small dock on a projecting point of land near the town, others at private landings on the haciendas. The haciendas of Bais are not spread out over so great an area as in other districts, but are fairly well crowded together in a level plain nearly surrounded by mountains, having a total extension north and south of 6 kilometers, and inland from the coast from 2 to 3 kilometers, a large proportion of this area being cultivable sugar land. Thirteen kilometers south of Bais is the barrio of Tanjay, containing

some thousand hectares of fairly good sugar land, little of which is at present under cultivation, while 10 kilometers to the north is located the barrio of Manjuyod, with approximately the same amount of land, also uncultivated. Several small streams run through the district, but are of no use for navigation. Land transportation, aside from that along the provincial road to Dumaguete, is restricted to private roads kept up by the individual haciendas.

Area and production of the district of Bais (1908).

	Amount.	
	<i>Hectares.</i>	<i>Per cent.</i>
Number of growers, 18.		
Area of growers' land planted in sugar cane	1,688	58.9
"Area of growers' land suited to cane culture but not planted	1,157	40.4
Other land suited to cane culture but not planted	20	0.7
Total sugar land	2,865	
Average amount of sugar land in hectares owned by each grower:		
Planted	93.8	
Unplanted	64.3	
Total	158.1	
	<i>Piculs.</i>	<i>Metric tons.</i>
Average amount of sugar produced by each grower	4,251	268.8
Average amount of sugar produced per hectare planted	45.3	2.87
Total sugar produced	76,509	4,839

Since the individual grower here owns more land and has a larger amount under cultivation than in the majority of other parts of Negros, he naturally produces a relatively greater amount of sugar, being in this respect second only to the average grower of San Carlos, but the yield per hectare of land planted is only a trifle higher than the general average for the island and less than half of what it should be in a district so fertile as Bais. As in other regions, much of the land here reported to be planted in sugar cane is, for the greater part through lack of capital, so poorly cared for that the apparent yield per hectare of the district as a whole is thereby considerably reduced.

The sugar soils of Bais are in general appearance and chemical composition much like those of Ilog-Cabancalan, which lies just across the mountains on the opposite side of the island, and are locally classified into the same three main types according to texture, those of Bais running perhaps more to the "tierra mestiza" and heavy clay lands, the latter being termed on this side of the island "lamákan" instead of "bankil." The following analyses of soils taken from different haciendas throughout the entire district represent very well the average composition of the sugar lands of Bais:

Soil analyses, district of Baïs.

Soil No.	Nature of soil.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Volatile matter.	Remarks.
			Perct.	Perct.	Perct.	Perct.	Perct.	Perct.	Perct.	
74	Surface	100.0	0.38	0.40	3.61	2.35	0.22	0.17	10.10	Hacienda Rosario. A composite sample from four different fields, but all very much the same in appearance; said to yield up to 150 piculs (9.50 metric tons) sugar per hectare. Surface soil sandy loam ("tierra bombon"); subsoil at 25 to 30 centimeters, a mixture of fine yellow sand and some clay; at 60 centimeters, nearly all sand. Cane is said to grow well in this soil even in very dry or in very wet weather.
74 A	Subsoil	100.0	.25	.22	6.61	2.22	.15	.11	10.10	
75	Surface	100.0	.43	.28	3.20	2.22	.24	.16	10.82	Hacienda Tamugun, farther back toward the mountains "Tierra mestiza," somewhat heavier soil than number 74; very good cane land; subsoil at 30 to 35 centimeters, very little different from surface; at 65 centimeters, heavy black clay.
75 A	Subsoil	100.0	.83	.18	2.97	1.98	.14	.13	9.72	
76	Surface	99.9	.27	.12	3.19	1.89	.15	.16	13.30	Hacienda Paz. Light clay loam, good cane soil; subsoil at 25 centimeters, black clay.
76 A	Subsoil	99.9	.25	.10	3.08	1.94	.11	.12	11.67	
77	Surface	97.8	.40	.40	2.91	2.19	.19	.13	9.50	Hacienda Consolacion. "Tierra mestiza," surface black clay loam; subsoil mixture of black clay and yellow sand; said to yield 90 to 100 piculs (5.70 to 6.33 metric tons) per hectare.
77 A	Subsoil	98.7	.27	.18	5.27	2.21	.16	.10	9.42	
78	Surface	94.4	.46	.51	2.91	1.98	.20	.14	10.34	Hacienda Valencia. A mixed soil, very similar to number 77.
78 A	Subsoil	96.0	.28	.25	5.24	2.08	.15	.10	9.60	
79	Surface	98.8	.29	.10	.85	1.46	.09	.12	10.40	Hacienda Pilar. "Lamakan" heavy black clay, uncultivated at present; said to produce good quality of cane, but rather small. In very wet years cane does not grow well, owing to lack of drainage; subsoil at 20 centimeters, very stiff black clay.
79 A	Subsoil	99.1	.31	.08	1.00	1.77	.07	.09	10.47	
80	Surface	99.3	.26	.06	1.68	1.55	.11	.19	11.93	Hacienda Pilar, land near sea. Said to be very good cane land in dry years, but somewhat doubtful if much rainfall; has some drainage toward sea; subsoil at 20 centimeters, stiff black clay.
80 A	Subsoil	99.8	.21	.08	1.78	1.62	.06	.09	11.38	
81	Surface	100.0	.32	.23	6.52	2.38	.13	.12	10.60	Hacienda Cambulao. Black clay soil; very good land; subsoil at 30 centimeters, yellow clay.
81 A	Subsoil	100.0	.26	.22	5.39	2.24	.14	.11	9.76	
82	Surface	97.6	.12	.31	2.53	2.01	.17	.14	10.29	Hacienda Tankulugan, northern part of Baïs. "Tierra mestiza" or "mixed" soil; subsoil at 25 centimeters, yellow clay and fine sand; at 55 centimeters, nearly all sand, some rather coarse.
82 A	Subsoil	88.0	.24	.31	5.66	2.06	.14	.08	9.27	
83	Surface	100.0	.40	.22	2.36	1.93	.19	.14	10.44	Hacienda Biñojon, northern part of Baïs, near seacoast. Surface soil similar to number 82, subsoil somewhat finer sand and rather more clay in proportion.
83 A	Subsoil	100.0	.28	.23	3.90	2.20	.15	.11	9.81	

Soil No.	Nature of soil.	Detritus on 1-mm. screen.	Mechanical analyses of samples (5 grams) of material, district of Bais, passing a 1-mm. screen. Samples as prepared for chemical analysis.						
		>1 mm., gravel.	1.0-0.5 mm., coarse sand.	0.5-0.25 mm., medium sand.	0.25-0.10 mm., fine sand.	0.10-0.05 mm., very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.	Total.
74	Surface	0.0	0.41	1.76	9.20	29.36	45.52	14.22	100.50
74A	Subsoil	0.0	0.43	2.64	12.69	28.69	45.18	10.79	100.48
76	Surface	0.1	0.14	0.80	8.74	15.24	50.88	23.64	99.44
76A	Subsoil	0.1	0.24	0.94	12.80	19.32	43.00	23.42	99.72
79	Surface	1.2	1.05	2.86	5.15	4.57	43.53	42.44	99.60
79A	Subsoil	0.9	0.66	2.18	4.92	5.76	50.89	36.12	100.53
80	Surface	0.7	0.12	0.84	4.98	11.12	43.88	39.12	100.06
80A	Subsoil	0.2	0.14	0.76	6.22	13.68	49.80	29.66	100.26
83	Surface	0.0	0.10	0.80	8.98	26.10	47.92	15.72	100.02
83A	Subsoil	0.0	0.10	0.96	12.94	33.40	41.78	11.26	100.44

Chemical composition.

Nature of soil.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Volatile matter.
	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
Surface	98.78	0.36	0.26	2.98	2.00	0.17	0.15	10.77
Subsoil	98.15	0.27	0.22	4.09	2.03	0.13	0.10	10.12

Physical composition.

Nature of soil.	>1 mm., gravel.	1.0-0.5 mm., coarse sand.	0.5-0.25 mm., medium sand.	0.25-0.10 mm., fine sand.	0.10-0.05 mm., very fine sand.	0.05-0.005 mm., silt.	<0.005 mm., clay.	Total.
	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
Surface	0.4	0.37	1.41	7.40	17.36	46.35	27.03	99.92
Subsoil	0.3	0.32	1.50	9.91	20.17	46.13	22.25	100.28

Practically all the soils of Bais are locally considered to be excellent sugar producers, and the same fact is indicated by chemical analysis, they being especially rich in potash and lime and somewhat above the average in phosphoric acid and nitrogen. As in Ilog-Cabancalan, much of the lime is present as the carbonate. Apparently, Bais has an abundant yearly rainfall, as I am informed that the cane there hardly ever suffers from drought, the only complaint being that in especially wet years, cane growing in the "lamakan" soils is apt to be injured by the abundance of water, which does not filter well through the heavy clay subsoil. To obviate this danger it is customary to commence planting rather early, so as to finish before March at the latest, and get a good stand of cane before the onset of the rainy season

in June or July. Efficient canalization also is found to be of great help in reducing the loss occasioned by water stagnating on the fields.

Just one soil of the entire district, number 79, is reported as being unproductive for sugar growing. In the past it has been cultivated to a certain extent, but never successfully except in extremely dry years, when it is said to produce a cane small in size, but of very good quality. Several years ago the owner sustained such severe losses through having almost the entire crop of cane planted on this land killed by too much rain, that some 400 hectares of it have been completely abandoned as far as sugar raising is concerned. Analysis shows this soil to be fairly rich in everything except lime, in which it is very deficient compared with other soils of the district. In physical composition it is shown to contain more clay and silt, and less sand than the soil from other parts of the district. An attempt is now being made to improve this field by means of deep drainage ditches as a protection against stagnant water. Judging from the surrounding country, it is quite possible that treatment with lime up to 10 or even more tons per hectare might be of great help in loosening up this soil and destroying the plasticity of the clay, although of course the value of such treatment could only be determined with certainty by actual tests on small portions of the field itself.

At the time of my visit to Bais all of the estates had finished grinding. It was therefore impossible to procure samples of cane for analysis; but, according to statements made by the planters, the cane here presents no marked difference from that found in other portions of Negros. The proportion of plant cane to ratoons is said to be about the same as in Ilog-Cabancalan.

THE SOIL OF NEGROS COMPARED WITH THAT OF OTHER SUGAR-PRODUCING COUNTRIES.

AVERAGE COMPOSITION OF NEGROS SOIL.

The following table shows compactly the average composition of the surface and the subsoils of each of the important sugar districts of Negros, together with the general average for the entire island:

Average composition of the sugar soils of Negros.

SURFACE SOILS

No.	District.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Vola- tile matter.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
1	Silay, etc	98.17	0.05	0.09	0.52	0.45	0.09	0.11	6.55
2	Bago	98.43	.11	.07	.38	.25	.10	.10	9.57
3	Pontevedra-La Carlota	93.03	.14	.20	.79	.31	.17	.17	10.68
4	Binalbagan-Isabela	99.76	.15	.18	1.50	.88	.20	.14	10.01
5	Ilog-Cabancalan	99.51	.21	.20	3.51	1.34	.19	.13	8.91
6	San Carlos	94.03	.40	.24	1.94	1.60	.15	.17	8.67
7	Bais	98.78	.36	.26	2.98	2.00	.17	.15	10.77
	General average	97.39	0.20	0.18	1.66	0.98	0.15	0.14	9.31

SUBSOILS.

No.	District.	Fine earth.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Volatile matter.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
1	Silay, etc	96.04	0.04	0.09	0.52	0.45	0.6	0.09	8.29
2	Bago	98.47	.11	.07	.41	.23	.08	.07	10.08
3	Pontevedra-La Carlota	89.60	.14	.22	.88	.32	.14	.11	10.09
4	Binalbagan-Isabela	99.76	.13	.14	1.15	.91	.15	.10	10.10
5	Ilog-Cabancalan	99.52	.19	.21	3.36	1.31	.17	.09	7.67
6	San Carlos	91.17	.32	.24	1.80	1.67	.12	.11	8.01
7	Bais	98.15	.27	.22	4.09	2.03	.13	.10	10.12
	General average	96.10	0.17	0.17	1.79	0.99	0.12	0.10	9.19

Mechanical analyses of Negros soils; averages for the different districts.

SURFACE SOILS.

No.	District.	Detritus on 1-mm. screen.	Analyses of samples (5 grams) of material passing a 1-mm. screen. Samples as prepared for chemical analysis.						Total.
			>1 mm., gravel.	1.0-0.5 mm., coarse sand.	0.5-0.25 mm., medium sand.	0.25-0.10 mm., fine sand.	0.10-0.05 mm., very fine sand.	0.05-0.005 mm., silt.	
1	Silay, etc	2.2	0.94	4.74	14.76	23.48	33.59	22.20	99.71
2	Bago	1.0	1.53	7.05	12.70	21.30	34.04	23.28	99.91
3	Pontevedra-La Carlota	7.0	3.03	10.33	12.66	13.49	34.66	25.93	100.10
4	Binalbagan-Isabela	0.2	0.39	3.18	11.07	15.87	48.74	20.51	99.75
5	Ilog-Cabancalan	0.2	0.13	1.61	13.27	29.53	42.27	13.42	100.22
6	San Carlos	7.6	2.49	9.47	13.57	15.58	39.58	19.26	99.94
7	Bais	0.4	0.37	1.41	7.40	17.36	46.35	27.03	99.92
	General average	2.7	1.27	5.40	12.20	19.51	39.89	21.66	99.94

SUBSOILS.

1	Silay, etc	3.3	0.90	4.49	14.20	21.24	33.31	25.83	99.97
2	Bago	0.8	1.25	5.86	13.99	19.65	33.91	25.21	99.86
3	Pontevedra-La Carlota	12.0	3.89	11.85	13.04	11.30	33.43	26.69	100.21
4	Binalbagan-Isabela	0.3	1.05	3.58	10.45	19.94	43.91	20.85	99.75
5	Ilog-Cabancalan	0.3	0.21	2.87	16.67	24.74	42.36	12.91	99.76
6	San Carlos	10.4	2.72	10.23	13.90	14.62	36.95	21.59	100.01
7	Bais	0.3	0.32	1.50	9.91	20.17	46.13	22.25	100.28
	General average	3.9	1.48	5.77	13.17	18.81	38.57	22.19	99.99

Considered as a whole, they may be said to be decidedly high in lime, but only moderately so, although containing an ample sufficiency in potash, phosphoric acid, and nitrogen for profitable sugar-cane growing. As all but a small percentage of the entire soil is "fine earth"—that is, the portion passing a sieve 1 millimeter in diameter, which is

taken as the final sample upon which the analyses are based—it follows that in a given area of land considerably more nutritive matter is actually present than in a land of coarser texture, where the fine earth might amount to only 30 to 40 per cent of the whole, even though the latter appeared on analysis to be somewhat richer.

HAWAIIAN SOILS.

Below is given the average analysis of soils in the Hawaiian Islands:⁷

Island.	Potash.	Lime.	Phosphoric acid.	Nitrogen.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Kauai	0.358	0.504	0.237	0.246
Hawaii	0.353	0.833	0.320	0.388
Oahu	0.348	0.411	0.269	0.119
Maui	0.401	0.691	0.200	0.222
General average	0.365	0.609	0.256	0.243

Omitting the third decimal place as a rather unnecessary refinement in soil analysis, it will be noted that these Hawaiian soils, which under intensive cultivation and irrigation are the most highly productive in the world, run from one and a half to two times higher in potash, phosphoric acid, and nitrogen than the general average of soils from Negros, although their superiority is not so marked when compared with the richer districts of San Carlos and Bais. In lime they are very much lower.

EGYPTIAN SOILS.

Analyses of the narrow strip of alluvial soil along the Nile, in upper Egypt, where much sugar cane is grown, are given by Tiemann:⁸

Locality.	K ₂ O.	Na ₂ O.	CaO.	MgO.	P ₂ O ₅ .	N.	Loss in calcinating.
	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
Cheik Fadl	0.88	0.89	5.31	2.79	0.23	0.04	1.82
Do	1.33	0.95	5.84	3.14	0.38	0.04	5.49
Charkieh	0.72	1.31	3.34	1.99	0.25	0.48	6.62
Do	0.87	1.16	2.27	2.95	0.37	0.21	8.38
Yellow earth at Beni Mazar	0.7	0.56	4.36	1.76	0.21	0.66	4.21
Black earth at Beni Mazar	1.88	2.16	3.39	2.57	0.29	0.43	6.9
Average	1.06	1.17	4.09	2.53	0.29	0.31	6.07

Although these are decidedly richer in every respect than the famous Hawaiian soils, yet they are spoken of by Tiemann as being "exhausted" and in need of artificial fertilizers, a fact which would tend to support the theory that the so-called "exhaustion" of soils is more often than not due to other causes than simply a lack of sufficient mineral plant food.

⁷ Report of Work of the Experiment Station of the Hawaiian Sugar Planters' Association, Div. of Agr. and Chem. Bull. No. 15, 1905, p. 7.

⁸ The Sugar Cane in Egypt, p. 18.

The following analyses of sugar soils collected from various sources are quoted from Deer, "Sugar and the Sugar Cane."

LOUISIANA SOILS.^a

Potash.	Soda.	Lime.	Magne- sia.	Phos- phoric acid.	Nitro- gen.
<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
0.092	0.158	0.394	0.087	0.068	0.097
0.162	0.142	0.313	0.025	0.126	0.130
0.233	0.081	1.494	0.039	0.098	0.060
0.717	0.181	0.910	1.361	0.146	0.085

^a Quoted originally by Stubbs in "Sugar Cane."

Stubbs concludes that the average composition of Louisiana soils is lime, 0.5 per cent; potash, 0.4 per cent; phosphoric acid, 0.1 per cent; nitrogen, 0.1 per cent.

JAVA SOILS.^a

Sand.	Cal- cium carbon- ate.	Lime.	Magne- sia.	Potash.	Phos- phoric acid.	Nitro- gen.
<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
9.6	1.38	2.52	0.18	0.14	0.19	0.08
26.2	0.02	0.95	0.19	0.12	0.11	0.07
53.4	0.02	2.21	0.17	0.06	0.07	0.06
40.2	0.05	2.48	0.26	0.05	0.07	0.14
45.6	0.00	1.08	0.17	0.05	0.04	0.03
4.2	0.02	0.68	0.10	0.05	0.06	0.09

^a By Kramers, and quoted by Kruger in "Das Zuckerrohr."

These soils are considered decidedly poor in every constituent except lime, and yet Java is producing from them, by scientific methods of cultivation, over 10 metric tons of sugar per hectare per annum, over three and one-half times the present yield in Negros.

DEMERARA SOILS.^a

The first had been in cultivation for five and the second for over sixty years. The third is a Queensland soil quoted from the same source.

Potash and soda com- bined.	Lime.	Magne- nesia.	Phos- phoric acid.
<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
0.11	0.64	0.50	0.08
0.10	0.11	0.36	0.05
0.20	0.56	0.26	0.06

^a Analyzed by Phipson and quoted by Locke and Newlands.

SOILS FROM BERBICE.^a

Nature of soil.	Potash and soda com- bined.	Lime.	Mag- nesia.	Phos- phoric acid.	Nitro- gen.
	Percent.	Percent.	Percent.	Percent.	Percent.
1. A heavy clay, under cultivation for a number of years -----	0.50	0.27	0.15	0.19	0.95
2. Virgin forest soil - - - - -	0.53	0.28	0.17	0.19	0.97

^a Analyzed by Deer.MAURITIUS SOILS.^a

Lime.	Potash.	Phos- phoric acid.
Per cent.	Per cent.	Per cent.
0.419	0.199	0.156
0.475	0.188	0.129
0.389	0.155	0.105
0.163	0.121	0.221

^a Analyzed by Deer.

COMPARISON OF NEGROS SOILS WITH THOSE OF OTHER COUNTRIES.

Comparing all these soil analyses, it will be seen that, although not preëminently rich in most constituents, the soil of Negros may rightfully be classed as among the better of the sugar lands of the world, and, given the proper care in cultivation, should be able to yield eventually as much sugar in proportion to the area of ground planted as any other country depending for its supply of water on its natural rainfall. Practical experience in cane culture tends to establish the fact that production depends more upon careful and intelligent cultivation than upon any inherent richness in plant food possessed by the soil itself, granted, of course, as a starting point a land not utterly deficient in these necessary elements of nutrition. An example of the truth of this statement is the relative productivity of different parts of the Hawaiian Islands. In comparing different sugar-producing countries, Hawaii is almost invariably placed in the lead without a rival, because of "the enormous fertility of her soil," both fertility and average yield being often grossly exaggerated.

Geerligs^a gives statistics regarding the total production of the Hawaiian Islands in recent years, from which it is seen that the average yield of all the land under cultivation during the ten years ending with 1906 was 9.997 metric tons per hectare; the arid portions of the islands, provided with expensive irrigation

^a De Rietsuikerindustrie in de verschillende landen van Productie. *De Indische Mercur* (1909), 32, 897.

systems, produced in the same time 13.133 metric tons per hectare, while those parts depending on natural rainfall averaged only 7.241 metric tons per hectare. This latter figure, corresponding to about 115 piculs per hectare, is nearly three times the average yield in Negros, but is often equaled and even exceeded on fields of considerable extent in some of the better cultivated plantations, not only in the richer, but also in the poorer soils of the island. Java, with a soil much poorer than that of Negros, yields on the average fully as much sugar per hectare as the Hawaiian Islands. The Island of Hawaii, which is largely dependent on rain, but little irrigation being practiced, averages, in production per extent of land planted, about half as much as the well-irrigated Oahu. From the analyses of Hawaiian soils previously quoted, it is shown that the soil of Hawaii is chemically decidedly superior to that of Oahu. Geerligs goes on to state that "it is seen, on the whole, that the soil of the Hawaiian Islands does not give such an enormously high yield of sugar as is commonly attributed to it by writers on the subject. The popular impression to the contrary comes from the fact that there are in the neighborhood of Honolulu (on the Island of Oahu) a few estates of extra fertile land, especially well cultivated and provided with perfect irrigation plants, so that here extraordinarily large crops of cane and sugar are produced. As the majority of tourists do not get any farther away than the outskirts of Honolulu, the conditions existing there are too readily generalized, and reports come out that in Hawaii they get 12 tons of sugar per acre—that is, 26.88 metric tons (430 piculs) per hectare."¹⁰

While Negros, handicapped as it is by severe tropical rains during a large part of the year, may never hope to rival the irrigated lands of the Hawaiian Islands, where water is supplied only when needed, there is no reason why it should not eventually produce fully as much sugar per hectare as the non-irrigated portion of that country, provided it is found profitable to expend the same amount of care and money in cultivation and fertilization.

FERTILIZATION IN NEGROS.

The great majority of planters in Negros at the present time pay absolutely no attention to fertilizing the soil, but reap crop after crop with apparently no thought for the future. In some of the less productive, districts, such as Silay and parts of Bago and La Carlota, diminishing yields are beginning to force this subject to their attention, and some attempts are being made toward improving the soil, chiefly by means of animal manure, a poor field being fenced off for a season and used as a "toril" or inclosure for the work animals. In a few places, also, the necessity of returning scums and bagasse ashes to

¹⁰ It is needless to state that the Hawaiian planters are in no way responsible for these exaggerated reports. Accurate data concerning the sugar production there have always been available to anyone who cared to take the trouble to look them up. Mr. Geerlig's remarks upon the subject are quoted here, not in any disparagement of Hawaii, but rather to correct the impression, too prevalent among the planters of Negros, that such enormous yields are the general rule in other sugar-producing countries, and therefore would be possible here were similar methods of cultivation and manufacture to be followed.

the fields is becoming appreciated, although the latter are more frequently used for improving the "plaza" and the roads near the mill. Lime is sometimes employed, although to a very limited extent. In one place I was informed that several fields had recently been treated with slaked lime to the extent of about 200 liters per hectare. When asked with what object, the native foreman replied that the cane from these fields yielded a juice which required an excessive amount of lime for its defecation; his idea being to save lime in the sugar house by adding it to the soil! The use of artificial fertilizers is almost unknown, this not being the fault of the planters so much as because thus far no reliable fertilizers have been offered for sale in the Iloilo market at prices anywhere nearly commensurate with their real value. The amount of mineral matter removed from the soil by a crop of sugar cane is not excessive, and, provided the greater part of this is returned to the fields each year in the form of bagasse ash and factory waste, there is apparently very little need of extra fertilizers if these are considered simply as a means of replenishing plant food in the soil.

Analyses of bagasse ash from different parts of Negros indicate that the cane grown there is comparatively low in mineral matter, as might be expected from its low fiber content. Three samples of bagasse ash collected by me from mills in the districts of Bago, Ilog-Cabancalan, and San Carlos were analyzed by Mr. R. R. Williams, of the Bureau of Science, with the following results:

Analyses of bagasse ash.

Constituents	1. Hacienda, Lumangub, Bago, Occidental Negros.	2. Hacienda, San Isidro, Cabancalan, Occidental Negros.	3. Hacienda, San Jose, San Carlos, Occidental Negros.
	Per cent.	Per cent.	Per cent.
Water (H_2O) at 110°	0.77	0.68	1.32
Loss on ignition	1.43	1.01	4.61
Silica (SiO_2)	63.91	68.50	64.27
Ferric oxide and alumina (Fe_2O_3 , Al_2O_3)	15.22	10.22	11.42
Lime (CaO)	4.27	5.79	3.85
Magnesia (MgO)	2.54	1.96	2.83
Potash (K_2O)	8.14	8.28	8.16
Soda (Na_2O)	4.13	3.66	3.20
Phosphoric acid (P_2O_5)	0.60	0.60	0.59
Sulphuric acid (SO_3)	0.08	0.15	0.13
N	0.01	0.01	0.03
Total	101.09	100.88	100.38

* All the samples contained ferrous iron to such an extent that many particles of ash were attracted by the magnet. As no determination of ferrous iron was possible on account of carbonaceous matter, no correction has been made in totalling.

These samples do not vary in composition to as great an extent as might be expected, when it is considered that the soils in which these canes were grown are of widely different chemical composition, especially as regards their content of potash. Since no data are at present available as to the ash of the entire cane, which may vary decidedly from that of the bagasse, it is impossible to calculate even approximately the amount of mineral matter taken from the soil by the Negros cane.

Deer¹¹ quotes from Stubbs, who, from experiments covering a period of ten years, calculates the amount in pounds of mineral matter removed per ton of the Louisiana Purple cane as follows:

Nitrogen	2.98
Phosphoric acid	1.63
Potash	2.52
Lime	2.54

Expressed in kilograms per metric ton of cane, these figures would correspond to:

Nitrogen	1.33
Phosphoric acid	0.73
Potash	1.12
Lime	1.13

Assuming a crop of 6 metric tons or 95 piculs of sugar, a little over twice the present average in Negros, which would correspond roughly to 60 metric tons of cane, there would be removed from the soil annually in kilograms per hectare of land the following amounts of mineral matter:

Nitrogen	79.8
Phosphoric acid	43.8
Potash	67.2
Lime	67.8

Now, in 1 hectare of land, from the surface to a depth of 20 centimeters, or the average depth to which the cane roots penetrate, there are 2,000 cubic meters of soil of an approximate apparent specific gravity of 1.5, or 3,000,000 kilos. One-hundredth of 1 per cent of this, the smallest difference which can be detected by an accurate chemical analysis, would amount to 300 kilograms of any one element, so it may be readily seen that at least five, and more probably ten, years would be required before any depletion of the soil from successive crops of sugar cane would be suggested by chemical analyses, even if absolute accuracy in sampling and in analytic methods were assumed, not to mention the greater changes which might be brought about during such a long period of time by mineral matter carried up from greater depths by the soil water, or carried away by rains.

These figures make no pretense at even moderate accuracy, but serve to illustrate the relatively small order of magnitude of changes in the composition of a soil which may be brought about by the cultivation of sugar cane. It is likewise apparent that the ordinary commercial fertilizers would need to be used in quantities of many tons to the

¹¹ *Loc. cit.*

hectare before any improvement in the soil as regards its actual composition could be detected. This should not be construed as an argument against the use of fertilizers, for they are undoubtedly at times of great benefit, even in very fertile soils, but the way in which they act and indications for their use, although the matter has been carefully studied for many years in all parts of the world, are very little understood.

Cameron¹² states the most modern views on this subject as follows: "Soil chemistry is a very complex subject, into which we are just beginning to get glimpses, and the supply of mineral nutrients is only one of the important details in a very intricate problem. * * * It is of course patent to everyone that fertilizers sometimes, in fact frequently, produce larger crop yields. Sometimes the contrary is true, but it is absolutely certain that at the present time no one can, nor are there any methods available by which one can, safely predict what fertilizers and how much should be used."

It would appear, then, that the question of the extent to which fertilizers may profitably be employed on the soils of Negros, or of any other sugar-producing country, is largely one of bookkeeping rather than of chemistry and can be determined for a given locality only by actual field experiments in that locality, and by the profit-and-loss accounts of the plantations on which these experiments are made.

THE CANE OF NEGROS.

AVERAGE COMPOSITION OF THE SUGAR CANE OF NEGROS.

The following table is deduced from the previously quoted analyses of the common purple or native cane found in four of the most important districts of Negros:

Average composition of the purple or native cane in Negros.

District.	Average weight per cane.	In cane.			In juice.		
		Su- crose.	Fiber.	Brix.	Su- crose.	Quo- tient of purity.	Re- ducing sugar.
		Kilos.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Bago.....	1.00	16.41	9.80	20.49	18.80	91.70	0.62
Pontevedra-La Carlota.....	1.14	14.01	9.30	17.91	15.79	87.99	0.99
Ilog-Cabancalan.....	0.79	16.95	9.81	21.18	19.30	91.67	0.49
San Carlos.....	0.76	16.87	11.20	21.85	19.72	90.19	0.77
Average.....	0.92	16.06	10.02	20.35	18.40	90.38	0.71

Since the purple variety is the only one grown to any extent in Negros, the above represents with a fair degree of accuracy the general run of sugar cane which may be encountered throughout the island. Below are given analyses of other varieties found in Negros. They are

¹² The Dynamic Viewpoint of Soils. *Jour. Ind. and Eng. Chem.* (1909), 810.

practically of no importance except for purpose of comparison, as, with the exception of a few fields of the black cane, they are at the present time only of occasional occurrence or cultivated solely in a few experimental fields.

Other varieties of cane grown in Negros.

No.	Average weight per cane.	In cane.		In juice.				Reducing sugar.	Remarks.
		Su- crose.	Fiber.	Brix.	Su- crose.	Quo- tient of purity.			
	Kilos.	Per ct.	Per ct.		Per ct.		Per ct.		
2	1.94	10.13	11.03	14.66	11.72	79.97	1.43		From experimental plot, Bureau of Agriculture experimental station, La Granja; soil number 4; variety, plant cane eleven and one-half months old, Hawaiian "Rose Bamboo."
3	1.10	10.08	10.02	13.88	11.39	82.00	1.07		Same soil and conditions as number 2; variety, Hawaiian "White Bamboo."
4	0.91	13.43	9.53	17.34	15.05	86.82	1.02		Same soil and conditions as number 2; variety, "Demerara 95."
5	1.34	12.96	11.80	17.62	15.24	86.50	1.10		Same soil and conditions as number 2; variety, "Tiboo Mird."
7	1.64	13.49	9.49	17.59	15.41	87.62	1.01		Same soil and conditions as number 2; variety, "Louisiana Striped."
8	1.00	15.31	11.26	19.48	17.95	92.15	0.61		"Caña Negra" or black cane, from hacienda Carmen Chica; said to be a native variety, sometimes found growing wild in the mountains. The natives use a decoction of the rind as a medicine.
9	1.43	12.20	8.37	16.18	13.75	84.96	0.88		Said to be third ratoon from Hawaiian Rose Bamboo; soil number 3, La Granja; canes apparently not fully mature.
11	1.61	13.84	10.41	17.50	15.91	90.88	0.71		Same field as number 9, but ripe canes selected.
30	0.78	15.05	11.80	20.88	17.54	88.99	1.76		Native "white" or rather yellowish canes, from soil number 17, hacienda Lumanigup, Bago. This variety is of infrequent occurrence and is never planted here.
40	0.50	12.27	15.48	18.26	15.07	82.52	1.62		A peculiar wild variety called "Sagao," said to occur only in the San Carlos district; very erect and slender, like a reed, with long joints; never planted, as it is very hard and apt to break the mill; grows well and resists drought.
41	0.78	15.62	14.07	20.92	19.18	91.70	0.39		Third ratoon black cane from hacienda Providencia, San Carlos. The original seed cane said to have been imported from Java; generally yields No. 1 sugar, although dark colored.
47	0.55	14.60	14.63	19.89	18.23	91.64	0.37		First ratoon black cane from soil number 66, hacienda Refugio, San Carlos; fourteen months old.
27	2.01	10.10	8.05	15.35	11.18	72.85	2.11		First ratoon native cane from soil number 21, hacienda Lumanigup, Bago. Canes very large and thickly grown, but most of them twisted, fallen over, and lying along the ground like vines; soil is said to be too rich for the cane.

The first five are varieties of canes grown in the small experimental plot at the Bureau of Agriculture experiment station at La Granja. They are much larger in size than is the rule in Negros, but are relatively poor in sucrose and purity and contain a large amount of reducing sugar. That these are not inherent qualities of the cane itself, but rather the effect of the soil in which they grow, is shown by comparing a native cane from the same plot, number 6, quoted in the table of canes from Pontevedra-La Carlota. It will be noted that even native cane in this locality differs widely from that in other parts of the islands. So far as I have been able to ascertain, none of these five varieties has been tried elsewhere in Negros, although during the past year a few plants were set out by some of the planters in the lower lands of the same district, more as a curiosity than anything else. Number 8 is said to be a wild, mountain variety, somewhat darker in color but otherwise differing only in a few minor points from the ordinary purple cane. Analysis shows it to be of very good quality, although a little hard and high in fiber.

Numbers 9 and 11 are said to be the third ratoons from Hawaiian Rose Bamboo. They are of much better quality than the original plant, and illustrate the tendency of canes growing in an exceptionally fertile soil to become sweeter, although often smaller, after several years of ratooning.

Number 27 comes from a small field of very rich virgin soil, previously mentioned as number 21, of the district of Bago. Although it has ratooned one year, it yields a juice so poor that only by mixing it in the mill with other better canes could a fairly good sugar be produced. The manager of the hacienda where this was grown states that from the first planting no sugar at all could be made, only molasses. Such soils as this which are considered too fertile for sugar cane, are occasionally met with in Negros, and it is customary to "chastise" them by planting closer together, allowing the cane to ratoon without turning over the land, dispensing with all cultural operations so as to permit of a good growth of weeds, and in general acting contrary to all rules of agriculture, with the idea that in time the over luxuriant growth will become discouraged and yield a smaller, sweeter crop.

Theoretically, the remedy should lie in just the opposite course—by planting farther apart, the cane roots would have an opportunity to spread out and form a firmer support for a large cane, and, more space being allowed for the penetration of air and sunlight, more favorable conditions for ripening would be afforded. The principal reason that very fertile soils in this country often produce a poor quality of cane would appear to be that, especially in the case of the purple native variety, which is normally low in fiber, the roots at the start are not sufficiently developed to support a heavy stalk, which, as a consequence, falls over on the ground, where it forms a tangled mass of vegetation into which light and air can not very well penetrate, the result being that the cane never has a chance to become fully ripe.

Number 30 is a white cane similar to that grown extensively in Luzon. It is not liked in Negros, as it is said to be harder and to yield a juice less rich than the purple, therefore it is never planted intentionally, but is only to be found here and there in isolated stools.

Number 40 is a "freak" cane said to occur only in the San Carlos district, where it is considered by some to be a natural hybrid between the true sugar cane and a coarse species of wild grass called locally "tigbau" (*Saccharum*

spontaneum Linn.). The cane itself, known as "sagao," grows very tall, slender, and erect, with long joints, and is very hardy, resisting drought especially well, but is so extremely hard that it can not be ground for fear of breaking the mill. Analysis shows it to be of very little value as a source of sugar.

Numbers 41 and 47 are ratoons from cane somewhat similar in appearance to the black Java variety, which is grown to a limited extent on some haciendas in San Carlos. It is considered a fairly good cane, although not liked as well as the purple variety because of being somewhat harder to grind. In composition it is a little lower in sucrose and decidedly higher in fiber than the latter, and consequently has a greater tendency toward an erect growth. It should prove of value for planting in sandy and over-rich soils, where the purple variety sometimes falls down badly and deteriorates in quality.

CANE IN THE HAWAIIAN ISLANDS.

Geerligs¹³ gives Hawaii credit for producing a sweeter and purer cane than almost any other country in the world, only that of Peru being able to rival it. Among the different factories there, the highest monthly averages of sucrose in the cane ground were, during the campaign of 1909, 16.01, 15.89, 15.81, and 15.85 per cent in the cane, these figures applying to Lahaina cane grown in the dry regions under irrigation. The cane was planted in June, 1907, it tasseled in November, 1908, and was grown from March to May, 1909; so that it had been in the ground, on an average, twenty-two months before cutting. However, ratoons a year old, grown under natural rainfall, had by no means so high a sugar content. The fiber in Hawaiian cane is stated to be on an average about 12.5 per cent, with a maximum of 15 and a minimum of 10 per cent. In comparison, our Negros cane is on the whole fully as rich in sucrose as that from Hawaii, and in addition contains decidedly less fiber, so that, under the same process of manufacture, it should allow of even a higher extraction. However, it must be admitted that these data are not absolutely comparable, since those from Negros are based on clean, stripped cane, although not selected, while the Hawaiian figures refer to what was actually ground in the factories, including the small amount of dirt and trash inevitably weighed as cane. Experience has shown that, in Negros at least, cane delivered at the mill contains from 1 to 3 per cent of trash, which would increase the figures of its fiber content when ground in the mill by an approximately similar amount, at the same time decreasing its percentage of sugar 0.2 to 0.5 per cent. Because of the greater care taken in handling the cane in the Hawaiian Islands, the difference there is probably by no means as great.

¹³ *Loc. cit.*

EGYPTIAN CANE.

Tiemann¹⁴ says that in Egypt, in a good and frost-free year, an average campaign content of 14 per cent of saccharose on the weight of the cane can be reckoned upon, whereas in stormy years, when the cane is laid low and frost puts in its appearance, farmers can only count on 12 per cent. He gives an analysis made in March, 1897, an exceptionally good year, of a field planted the year before:

Brix	19.2
Per cent sugar in juice	16.85
Quotient	87.9
Per cent sugar in cane	14.5
Per cent glucose	0.18
Average length of canes, 6 feet.	
Average weight of canes, 1.19 kilos.	
Average weight of leaves, 0.27 kilo.	

These especially good canes in Egypt would be considered to be of only fair quality by the average planter of Negros, and only fit for making "No. 3" or "No. 2" sugar at the best.

JAVA CANE.

Geerligs¹⁵ states that the average cane ground in 107 factories in Java in 1908 contained 12.30 per cent sucrose and 12.01 per cent fiber, on the weight of the cane, the average purity of the raw cane juice being 83.74. This could only be expected to produce "No. 3" sugar or worse in Negros.

LOUISIANA CANE.

Stubbs¹⁶ quotes the results for the ten years ending 1897 at the Belle Alliance factory as follows:

Tons cane per acre	23.39
Metric tons cane per hectare	58.73
Juice composition:	
Brix	15.00
Sucrose	11.78
Glucose	1.56
Purity	78.53

Under the present conditions of manufacture in Negros, such cane as this would hardly pay for the grinding, as it would only yield a very poor grade of "corriente" sugar—that is, one polarizing about 70.

¹⁴ *Loc. cit.*

¹⁵ Statistics of the Factory Results on a Number of Java Sugar Estates, *Int. Sugar Journ.* (1909), 11, 324.

¹⁶ *Louisiana Agr. Exp. Sta.* (1902), *Bull.* No. 70.

WEST INDIAN CANE.

Watts¹⁷ states the composition of the cane ground at the central factory at Antigua, British West Indies, during the year 1907 to be as follows:

Cane:	<i>Per cent.</i>
Sucrose	14.39
Fiber	15.07
First mill juice:	
Brix	20.58
Sucrose	18.51
Purity	89.09
Glucose	0.93
"Whole" juice:	
Brix	20.58
Sucrose	17.06
Purity	87.03
Glucose	0.88

This cane, although comparable with that of Negros in point of richness and purity of juice, would hardly be appreciated here because of the large amount of fiber which it carries.

NEGROS AS COMPARED WITH OTHER COUNTRIES IN RESPECT TO THE QUALITY OF CANE.

The foregoing comparative analyses establish rather conclusively the fact that, contrary to what is perhaps the general impression, based on the idea that "nothing good can come from the Philippines," the native cane ordinarily grown in Negros is, in respect to the richness and purity of its juice, equal to that of almost any other sugar-producing country in the world, and, having in addition a comparatively low fiber content, could hardly be improved upon in its adaptability to a thorough and economical extraction by milling. It would almost seem that there had been evolved here by an unconscious process of selection the type of cane most nearly suited to a country where mills are, as a rule, weak and inefficient, and where the quality of sugar produced depends almost entirely upon the original purity and concentration of the cane juice.

DESIRABILITY OF INTRODUCING OTHER VARIETIES OF CANE.

However, the fact that we are already the fortunate possessors of such a good quality of cane should not deter us from attempting to improve upon it. The sugar content of a cane is, as often as not, a function of soil and of climatic conditions rather than an inherent quality peculiar to a certain variety, and it is quite possible that other kinds of cane might be introduced here which would combine the good

¹⁷ *West Indian Bull.* (1908), 9, 91.

qualities of the varieties already present with a large size and greater yield per hectare. Furthermore, even if the native variety should still prove best for general cultivation, it is very advisable that each hacienda should have one or two other kinds available for planting in case of need, since costly experience in other countries has proved that where one variety of cane has been grown for a long time, to the exclusion of all others, it may suddenly succumb to the attacks of diseases, which, doing little damage at the start, after existing for many generations under exactly the same conditions, become much more virulent and parasitic in character toward the particular variety of cane which they have been attacking.

Such a condition of affairs, as shown by Tempany¹⁸ in the case of a certain variety growing in the West Indies, is more liable to occur with a soft and juicy cane than with one containing a larger amount of fiber. It may best be held in check by the temporary substitution of other varieties of more resistant cane.

THE CULTIVATION OF SUGAR CANE AND THE PRODUCTION OF SUGAR AS CARRIED ON AT THE PRESENT TIME IN NEGROS.

PREPARATION OF THE SOIL.

It is practically the universal custom in Negros to burn the cane fields immediately after removing the season's crop of cane, or as soon thereafter as weather conditions will permit, thus ridding the land of trash and leaving the ground in a fit condition for plowing without delay. This practice is of further value in that injurious insects which might otherwise breed in the decaying leaves and stubble are in a large measure destroyed, and the potash and phosphoric acid contained in the trash are made more readily available to the coming crop. It has the disadvantage, however, that practically all the nitrogen content of this vegetable matter is lost during the burning process, and a soil already comparatively poor in nitrogen is still more impoverished each year. However, results on the whole seem to justify burning the trash, as Philippine cane in general is remarkably free from disease and from insect pests.

Shortly after removing a crop of cane and burning a field—as a rule, between the months of November and April—if it is to be replanted for the coming season, the ground is first given a preliminary plowing, termed in Visayan “lusoc,” each field being plowed from two to six times before it is considered in fit condition for planting. If the field to be planted is one that has lain fallow from the previous year, this preliminary tillage of the soil may begin as early as July or August in order to have everything in readiness by the time the planting season begins.

¹⁸ The Passing of the Bourbon Cane in Antigua. *West Indian Bull.* (1909), 10, 34-54.

The old-style native wooden plow drawn by the carabao is still largely in the majority, and, although American plows are coming into more general use each year, it will probably be a long time before the native implement is entirely supplanted, as the latter has the advantage of cheapness and simplicity, and owing to its light draft (the ground is penetrated to a depth of only about 10 centimeters) is considered to be easier on the carabao. It is generally estimated that ten men, ten plows, and twenty carabaos can, for the first plowing, take care of a little over one hectare of land per day, depending of course very largely on the nature of the ground and the condition of the weather. Subsequent plowings require considerably less labor.

After the ground has been gone over from two to five times with the plow, followed in most cases by a harrow, it is laid out in rows preliminary to receiving the seed. These rows are about 15 centimeters deep and may be from 75 to 150 centimeters apart, according to the system of planting employed.

PREPARATION OF THE SEED.

Only the white tops of the cane are used for seed. These are either cut off while the cane is still standing in the field, or the cane may be cut down first and the tops removed later.

In either case they are cut before transporting the cane to the mill and piled in heaps on the ground, after which the uppermost portion of the green stalk and leaves are cut off with a bolo, leaving for planting a section of the cane top from 20 to 25 centimeters in length. These tops, or "puntas," as they are now termed, are, as a rule, loaded into carabao carts and taken to some convenient spot, where they are stored temporarily in a shed or under a roof of some kind to protect them from the sun.

During the early part of the planting season, and when the ground is sufficiently moist, the cane seeds are planted as soon as possible after cutting, without any preparation except husking, but in very dry weather it is customary to soak them in water for from one to three days before setting them out, thus hastening the sprouting it is believed, and rendering the seed more resistant to drought. Any convenient stream or ditch may be used for this preliminary soaking, but some haciendas have tanks or troughs especially constructed for the purpose. When it is considered that the "puntas" are ready for planting, they are taken from the water and stripped of the outer layer of dead leaves still adhering to them, then carted off to the fields for planting. Most of the work of preparing the cane seed is done by women and children, who are paid by contract so much per "laesa" of 10,000 tops.

PLANTING.

There are several different methods of planting in vogue in Negros, the most usual one, probably, being to plant in rows about 1 meter apart and to leave a space of about 40 centimeters from point to point between the seeds in the same row, thus using very nearly 25,000 seeds per hectare. Whatever the system of planting, it remains fairly constant for each

locality, so that the "lacsas"¹⁰ is often used as a unit for land measure, meaning in this case the area in which 10,000 cane seeds have been planted or might have been planted, and varying according to locality from one-third to one-half of a hectare.

The cane tops are thrust into the ground in a slanting direction at the bottom of the furrows, then packed around with loose dirt so that only a few centimeters project above the surface. This work is, as a rule, performed by men, each man having a boy assistant, who hands him seed from a basket as it is needed. In a few localities women and children plant as well as prepare the seed. Sometimes, more especially in dry years and toward the end of the season, tops are planted in pairs instead of singly, with the idea that if one fails to sprout the other will in all probability succeed. In using this method the distance between rows and between seed in the same row is correspondingly increased, so that very rarely will the number of plants in a hectare exceed 30,000. On the east coast of Negros, where drought is sometimes to be feared, cane is often planted by means of the "gajo" or "vara," a sharpened stick frequently provided with a sharp-pointed iron cap, which is thrust into the ground in a slanting direction to a depth of some 40 centimeters, forming a hole into which the seed cane is pushed, after withdrawing the planting instrument. The advantage claimed for this method of planting is that the seed is buried deeper in the ground and consequently withstands dry weather better than when planted by other methods, so that sprouting is surer, and although the young sprout is somewhat later in making its appearance above ground, its root system has by this time become so well developed that a strong growth is ensured. In the district of Bais, especially, this system of planting is much used. There the cane is often planted in squares instead of in running rows. Two canes are set at each of the four corners of a square in such a way that a space of about 1 meter is left between each pair of cane seeds; thus approximately 2,000 seeds are planted in each hectare of land. Cane planted in this way, it is stated, can be kept free from weeds by cross plowing without danger of injuring the young plants, whereas the system of planting in rows permits of subsequent plowing in one direction only, and the cane rows themselves must be kept clean, at considerable expense, with the hoe. On the other hand is the disadvantage, at least with plant cane, that planting in squares probably produces a lesser number of individual canes to the hectare, and, leaving a greater area of land unoccupied, incurs more expense for plowing, since not only is there more space to be kept free from weeds, but a longer time must elapse before the field of cane "closes up" and by its own shade prevents further weed growth. It would appear that planting in rows probably yields a heavier first crop, but that where several years of ratoons are desired the square system might be given the preference, as subsequent ratoons thus have more room to spread without choking up the rows and making plowing between the young cane impossible.

CULTURAL OPERATIONS AFTER PLANTING.

The amount of labor expended on the young cane during its growth depends of course very much upon local conditions as to weather, soil, etc., and upon the resources of the individual planter. The following notes apply more especially to the methods followed in the district

¹⁰ A native word meaning "ten thousand."

around Pontevedra and La Carlota but may be taken as fairly representative of the system employed throughout the whole Island.

Four or five weeks after planting, when the young sprouts are 30 to 40 centimeters high, the first plowing, called "pahulug," is made. This consists in plowing two furrows close along the cane in each row, so that the dirt is thrown away from the cane and toward the center of the row. If the plowing is simply to kill weeds, and dirt is neither taken away from or thrown up on the cane, it is called "tudling." Then, with a hoe, any weeds or dirt thrown up by the plow are cleaned off from around the cane. In districts where cane is planted in squares, "pahulug" is made by plowing two furrows between the cane in each direction, without the use of the hoe. Fifteen or twenty days later, if weeds have sprung up again, the operation of "pahulug" must be repeated. After this, no further labor is required except an occasional plowing or harrowing to keep down weeds until the month of May or June, or until the first rains begin and the operation known as "pasandig" is necessary.

Three furrows are plowed between each row, throwing the dirt up around the roots of the cane and making a shallow trench in the center between rows. This treatment, just the opposite to "pahulug," is to prevent water from standing around the roots of the young cane and injuring its growth. If, as sometimes happens, a considerable period of dry weather intervenes after the first rains, it may be necessary to repeat the "pahulug" once more, but as soon as the rainy season really sets in, generally in July, dirt is again thrown up around the roots of the cane, which should by this time have attained a height of about 2 meters. This final labor, called by the natives "pasaca," is similar to "pasandig," but four furrows are made between the cane rows instead of three, dirt is packed higher up around the cane, and a much deeper trench is left in the center. Sometimes a finishing touch is given by performing the labor called "lambon," which consists in banking up earth along the sides and ends of the rows with a shovel, and leveling off uneven spaces between the cane so as to leave no opportunity for water to collect around it. Such a practice is considered to be more ornamental than absolutely essential. The field is now considered "cerrado," closed up—that is, the cane has reached a sufficient height and strength of growth so that its own shade prevents the further growth of weeds—and it can be left alone until harvesting time.

CULTIVATION OF RATOON CANES.

The foregoing description applies to the cultivation of plant cane only. A decidedly large proportion of the total land under cultivation in Negros, however, is not replanted every year, but is allowed to ratoon, from two to eight crops being taken off without replanting. This is especially true in the rich soils of the districts around Ilog-Cabancalan, Binalbagan-Isabela, San Carlos, and Bais. Theoretically, cane planted in some of these alluvial soils, which are flooded and fertilized each year by silt brought down from the mountains by the overflow of a river, might go on ratooning indefinitely. Practically, the period between plantings is limited strictly by financial considerations.

Much time and expense are saved by not being obliged to replant. On the other hand, the yield from plant cane is as a rule greater than

even from first ratoons, and with each successive ratoon crop the total amount of sugar produced per hectare of land is decidedly diminished. This is partially due to the shorter time in which the cane is allowed to ripen. Owing to excessive rains prevalent in this country, cane must be cut every year, and the practice so common in Hawaii of allowing ratoons to ripen for eighteen months or more is here out of the question. A further obstacle, especially when canes are planted closely in rows, is the tendency of ratoons to spread out in every direction from the original plant, so that in the course of a few years the cane rows lose all semblance of regularity and proper tillage of the soil is rendered very difficult; thus many young ratoons are stunted in their growth by weeds.

From data which I have been able to gather on this subject, the yield of sugar, as made by the customary native process, from 1 hectare of good cane land in the more fertile districts may be estimated approximately as follows:

Plant cane, 100 piculs (of 63.25 kilos) or 6.33 metric tons; first ratoons, 80 piculs or 5.06 metric tons; second ratoons, 70 piculs or 4.43 metric tons; third ratoons, 60 piculs or 3.80 metric tons; fourth ratoons, 50 piculs or 3.16 metric tons. Cane which yields less than 2 metric tons of sugar to the hectare is here considered hardly to be worth the cutting. The length of time during which it is profitable to let cane ratoon also depends largely on the cost of labor and the total area of land available for cultivation. On a small plantation, if labor is cheap, it is considered good policy to replant nearly every year in order to get the utmost possible yield. With plenty of land at his disposal, especially in districts where labor and animals are scarce, the hacendero has better results by letting his cane ratoon as long as it pays to cut it. The average time between replanting in the districts where canes are generally allowed to ratoon may be taken as four years, so that of the total sugar produced in these districts about one-fourth will be from plant cane and three fourths from ratoons.

For the cultivation of ratoon cane or "kalaanang," as it is universally called here, it is customary as soon as possible after removal of the crop and burning the field to plow the "pahulug" and then with a hoe to take away the dirt from around the old plant, leaving its roots exposed to the air and the sun. The field is left alone for from four to six weeks to allow the outermost of the old roots to decay, being plowed or hoed just enough to keep down weeds, then another plowing throws dirt up around the young cane sprouts, and from this time on the treatment is much the same as for plant cane.

PERIOD OF GROWTH OF THE CANE.

The length of time during which the cane is allowed to remain in the ground varies from nine to fourteen months and will probably average between eleven and twelve. As each plantation grinds its own

cane, the exigencies of milling largely determine the time of cutting, and therefore the time of planting. Naturally, where the same fields are cultivated year after year without rest or change of crops, the average period of growth of the cane must be somewhat less than twelve months. If fields are planted only on alternate years this period may be somewhat lengthened. Sometimes an exceptionally long rainy season delays grinding for one or two months and correspondingly shortens the growth of next year's crop. When clear weather does come, every energy is expended to keep the mill running full force and properly supplied with cane, so that fields are often cut before they are fully ripe, much to the detriment of the sugar produced. Again, especially toward the end of the season, a prolonged dry period may occur, during which cane which happened to be planted late on the previous season and which had not yet attained maturity begins to succumb to the heat and must be cut down at once to avoid a total loss. I have seen fields of large cane of fine appearance, less than ten months old, which needed to be sacrificed in this manner, in part too green to produce good sugar and in part dead from heat and lack of moisture. This condition is, of course, not so likely to occur on the heavy clay soils as on the sandy or alluvial ones.

COST OF CULTIVATION.

This is a subject which has been so thoroughly and so energetically discussed during the past few years, and one concerning which it is possible to obtain such widely varying estimates, according to the point of view, that the seeker after truth enters upon it with considerable trepidation. Especially when calculated to the picul, pound, or ton of sugar produced does this cost of field operations show its widest variation, since, as has been shown previously, the yield in sugar from 1 hectare of land may be anywhere from 20 to 200 piculs (1.26 to 12.6 metric tons), according to the soil, climatic conditions, care and intelligence in cultivation and in manufacture, and many other equally important factors, whereas the actual labor expended on the land will vary within somewhat narrower limits. Still, it will generally be found that the greater the cost of cultivation per hectare of land the more sugar will be produced from it. In a few haciendas where the field labor is paid for by contract, the price for plowing, cutting seed, planting the cane, and keeping it free from weeds until ready to harvest is from 50 centavos to 2 pesos for each picul of sugar produced, averaging, as a rule, about 1 peso (15.80 pesos per metric ton), all work animals, plows, carts, etc., being furnished by the hacienda.

The following estimate, based upon the number of men required to perform the previously described field operations and the cost of labor

at 40 centavos per day, may give some idea of the approximate cost of cultivating 1 hectare of land. In estimating these costs an endeavor has been made to approximate what is customarily paid throughout Negros, rather than to give figures representing extremely economical, successful management, or the reverse. The data on which they are based were nearly all secured at first hand from the planters themselves, and as some of them comprise confidential information concerning particular haciendas, it has been deemed best to omit altogether any statement of the sources from which my information was derived.

Estimate of the approximate cost of plowing, planting, and caring for 1 hectare of land already under cultivation from the time the field is burned until the cane is ready for cutting, based on the cost of labor at the rate of 40 centavos per day, no charge being made for work animals, implements, or supervision.

Nature of work performed.	Number of carabao-days required.	Number of man-days required.	Cost in Philippine currency.
			<i>Pesos.</i>
Preliminary cleaning off of trash from the field-----	1	4	1.60
First plowing-----	18	9	3.60
Second plowing-----	12	6	2.40
Third plowing-----	8	4	1.60
Two harrowings between plowings-----	6	3	1.20
Fourth plowing, including preparation of furrows for planting-----	8	6	2.40
Cutting 30,000 cane tops for seed-----		10	4.00
Hauling seed to canal or deposit-----	3	3	1.20
Husking seed-----		4	1.60
Hauling seed to field-----	3	3	1.20
Planting 30,000 seed-----		10	4.00
First weeding (with hoe)-----		12	4.80
Replanting of 5 per cent of seed which failed to sprout-----		2	0.80
"Pahulug" (two furrows between rows)-----	8	4	1.60
Second weeding (with hoe)-----		12	4.80
"Pasandig" (three furrows between rows)-----	10	5	2.00
"Pahulug" (two furrows between rows)-----	8	4	1.60
Third weeding (with hoe)-----		10	4.00
"Pasaca" (final plowing of four furrows between rows)-----	12	6	2.40
Total-----	96	117	46.80

The above refers to the cost of plant cane only. Although no accurate data are available on the subject, it is a safe estimate that fully one-half of all the sugar produced in Negros comes from the so-called "kalaanang" or ratoons. If a field is allowed to grow for a second year without replanting, the cost of caring for it is, of course, diminished by the amount ordinarily spent on the preliminary plowing, cutting of seed, and planting. The cost of cultivating a ratoon crop would then be about as follows:

Estimate of the approximate cost of caring for 1 hectare of land already planted and allowed to ratoon without replanting from the time the first crop has been taken off and the field burned until the second crop is ready for cutting, based on the cost of labor at 40 centavos per day, no charge being made for work animals, implements, or supervision.

Nature of work performed.	Number of carabao-days required.	Number of man-days required.	Cost in Philippine currency.
			<i>Pesos.</i>
Preliminary cleaning of field.....		4	1.60
"Pahulug" (two furrows between rows).....	10	5	2.00
"Pacad" (cleaning dirt away from roots of old plant with hoe).....		14	5.60
"Tudling" (straight plowing to kill weeds).....	8	4	1.60
First weeding (with hoe).....		10	4.00
"Pasandig" (three furrows between rows).....	10	5	2.00
"Pahulug" (two furrows between rows).....	8	4	1.60
Second weeding (with hoe).....		10	4.00
"Pasaca" (final plowing of four furrows, banking up rows).....	12	6	2.40
Total.....	48	62	24.80

Thus, it will be seen that on the average for a fairly well equipped and managed plantation in Negros, growing half plant cane and half ratoons, there will be required for each hectare of land in cultivation the services of one carabao for 72 days and of one laborer for 89.5 days, at a cost for the latter of 35.80 pesos. The period of time over which these cultural operations extend, from the burning of the first field to the closing of the last, may be placed at approximately seven months of 25 working days each, or a total in each year of 175 working days, and for purpose of calculation it can be stated that 1 hectare of land requires for its cultivation $\frac{72}{175}$ or 0.441 "carabao-year," if the term may be admitted, and $\frac{89.5}{175}$ or 0.511 "man-year," the value of a man-year for field work being put at 70 pesos. If carabaos are not owned by the hacienda, but rented, or charged for as rented, at the rate of 50 centavos per day, a carabao-year would be worth 87.50 pesos, and the expense charged to cultivation would be almost exactly doubled. Perhaps the better way of calculating, however, is to charge for the bare cost in wages of men and figure in the work animals later together with the cost of implements and general equipment.

Land cultivated in the previously described manner may be expected to yield from 40 to 80 piculs (2.53 to 5.06 metric tons) of raw sugar per hectare and will average, between plant cane and "kalaanang," fully 60 piculs (3.79 metric tons), so that the average amount paid out in wages and maintenance of laborers for field work in cultivating and caring for the cane, when reduced to the unit basis of sugar produced, comes to 60 centavos per picul, or 9.49 pesos per metric ton.

This figure will undoubtedly be considered too high by some growers and too low by others, depending largely on the amount of ratoon cane they raise, but it approximates very closely the average cost throughout Negros. It may be objected, with some degree of truth, that the average production of Negros is not

60 piculs per hectare, but only 42.9 piculs. It will also be found true that those haciendas which produce much less than 60 piculs per hectare spend proportionally less in caring for their cane, so that the cost per unit of sugar raised thus tends to equalize itself.

Since each hectare of land planted in sugar cane under the previously stated conditions requires 0.441 carabao-year and 0.511 man year for its proper cultivation, the approximate number of animals and laborers needed for field work on a hacienda of a given size can readily be determined; thus on an average-sized plantation of, say, 150 hectares of cultivable land, 50 hectares of which are in plant cane, 50 in ratoons, and the remaining 50 uncultivated, there will be necessary some 44 carabaos and 51 laborers for field work in caring for the cane before it is harvested. All this refers to cultivation by the methods now in vogue. An American planter in Negros states, however, that by the use of disc plows for all operations except that of marking off cane rows for planting, and by a more liberal use of the harrow, he has succeeded in materially reducing the cost in animals and men required to take care of a field, and, at the same time, keeps his land in better condition than under the old methods. A few of the larger haciendas are equipped with steam plows, nearly all being of the direct traction type. These, in light soils and in dry weather, are said to do the same amount of work much more satisfactorily and at a less cost than is possible by means of carabaos, although they labor under the disadvantage of not being able to work well in wet or heavy clay. Quite recently a few sets of cable plows have been introduced, which have to a large extent overcome this latter difficulty and should prove a valuable acquisition to those who can afford them.

CUTTING THE CANE.

If cane tops are in immediate demand for seed, a whole field may be topped at once and then cut later as needed for grinding. If cut within two or three days after topping, there is said to be very little deterioration in the juice. Sometimes, during a temporary stoppage of the mill, enough cane is cut for several days' supply, a practice which at times leads to serious losses when, for instance, because of wet weather or some slight accident to the mill, grinding is delayed longer than was intended. I once saw a mill which was crushing some very good looking cane, but was turning out a sugar of 68.6 polarization and 17.1 glucose.

Juice from the mill was analyzed as follows: Brix, 20.86; sucrose, 16.18; purity, 77.6; glucose, 2.76. I was informed that this cane had been topped ten days previously, and owing to a breakdown in the mill had lain for five days after cutting before being ground! Twenty canes were taken at random from the lot, sections of about 20 centimeters in length cut from top and bottom of each, and the juice from tops, middles, and bottoms analyzed separately, with the following results:

	Tops	Bottoms	Middles
Brix	21.40	23.60	21.72
Sucrose	15.81	18.88	17.34
Purity	73.89	79.98	79.84
Reducing sugar	3.51	2.81	2.75
Reducing sugar per 100 polarization	22.2	14.9	15.9

Although the whole cane shows a decided deterioration, the tops have evidently suffered more than the rest. This fact is well known to most planters, who generally cut off a small portion from the top of the cane if it has been stored more than a few days before grinding. In some haciendas it is customary to cut down the cane before removing the top, or, again, the two operations may go on simultaneously, one gang of men cutting tops and another following them cutting and carrying out the cane. All this work is done with the ordinary, blunted native working bolo, locally termed "binangon." The native laborer in this, as in other work, follows the line of least resistance, and unless closely watched he is apt to find it easier to cut off the cane a goodly distance above ground rather than waste time and energy in cutting it level with the surface. It is not uncommon to see a field of stubble averaging 10 centimeters in height, which means a loss of some 5 per cent of total sugar right at the start.

A few haciendas in the district of Isabela make a practice of burning a field before commencing to cut cane. The plantation is divided up by roads into fields sufficiently large to supply the mill for two or three days, and each field is burned separately just before cutting. Nighttime is, as a rule, chosen, as there is not likely to be a strong breeze, the field being fired against the wind, with a guard of men stationed to prevent the spreading of fire to an adjacent field. It is claimed that practically no loss of sugar results from burning provided the cane is ground without delay.²⁰ When properly controlled, much time and labor is undoubtedly saved by this procedure, as all trash is removed at the start, leaving only the bare cane stalks to be handled. This is rather dirty work, but is easier on the men, and the cane comes to the mill clean and free from trash, which is another decided advantage.

TRANSPORTING THE CANE TO THE MILL.

Methods of transporting cane from the fields to the mill are numerous and varied. The larger, better-managed haciendas are fairly well equipped with light portable tramways, mostly of English, German, or Belgian make. The rails are quite light, running from 10 to 14 pounds per yard (approximately 5 to 7 kilos per meter), and, as the track is put up in short sections, it can be moved about easily from place to place in the fields, as needed. In some plantations a main line of semiportable track is used, and branches are run from this into the fields as feeders. Skeleton cane cars of iron with wooden bottoms form the rolling stock; they hold about 1 ton of cane, and are most economically drawn by Chinese bullocks, less frequently by carabaos. The carabao, although stronger, is slower and less adapted to this class of work. In some districts where work animals are scarce, men

²⁰ Geerligs [*Cane Sugar and Its Manufacture*, Manchester (1909) 72] corroborates this statement *as far as the immediate effect of fire is concerned*, by analytical data. However, on standing more than two or three days after being burned, a very rapid deterioration sets in.

are employed to push the cane cars. The gravity system is also used to some extent where the mill can be located on a lower level than the cane fields. The cars come down full of cane, controlled and helped over the level places by one man to each car, and are drawn back to the fields empty, in trains of five to ten, by work animals. Where tramways are not available and for long hauls, light four-wheeled wagons having a capacity of about 2 tons of cane, drawn by two animals, are often employed. The primitive two-wheeled carabao cart is also much in evidence. On one hacienda a steam traction engine is at times pressed into the service and made to pull three or four wagonloads of cane in a train. All the work of loading and unloading cane is done by hand, the cane loader not yet having made its appearance in this country.

COST OF CUTTING THE CANE AND TRANSPORTING IT TO THE MILL.

The cost of cutting cane when paid for by contract ranges from 12.5 to 20 centavos per picul (1.98 pesos to 3.16 pesos per metric ton) of sugar produced, according to the size and quality of the cane, the value of labor in the vicinity, and the planter's reputation for requiring careful and thorough cutting.

One man can, on the average, cut cane equivalent to about $2\frac{1}{2}$ piculs of sugar during the course of a day, which taking the average wage as 40 centavos, makes the amount paid for cutting about 16 centavos a picul (2.53 pesos a metric ton) of sugar, a figure not far from that paid by the average planter. Transportation costs are subject to somewhat greater variation, the lowest estimate I have heard quoted being 10 centavos per picul (1.58 pesos per metric ton) of sugar produced and the highest 25 centavos per picul (3.95 pesos per metric ton), the difference being occasioned by the greater or less distance of the fields from the mill and the facilities for transportation available. At these prices carts or wagons and work animals are supposed to be furnished by the hacienda. If done by day labor, about the same number of men will be required to load and unload cane carts and handle the animals as are needed to cut the cane, so that the average amount paid out for transportation of cane will likewise come to about 16 centavos per picul or 2.53 pesos per metric ton. In addition there will be needed from eight to twelve oxen ("vacas") and a corresponding number of cane carts for each 100 piculs (15.8 metric tons) of sugar made per day.

MANUFACTURE OF SUGAR FROM THE CANE.

EXTRACTION OF THE JUICE.

Mills.—The sugar mills of Negros may be divided into three classes—first, those driven by steam; second, those run by water power; and, third, those using carabaos or oxen as a motive power. Of these, the steam mills greatly predominate; the carabao mills, or so-called "molinos de sangre," are so rapidly disappearing that, in the course of six months spent in the more important sugar districts, I was only able to see three of them in actual operation; while the water-power mills are

nearly all confined to small haciendas in the interior of the districts of Bago and La Carlota (La Castellana), where small mountain streams afford power enough to grind from 30 to 60 tons of cane per day.

The steam mills are practically all of English or Scotch origin, of the ordinary 3-roller type, driven by direct-gear connection with a single-cylinder engine running at from 40 to 80 pounds' steam pressure, and rated at a nominal horsepower of from 6 to 16, the average throughout the island being about 8 to 10. It is calculated roughly that each horsepower possessed by an engine is capable of grinding sufficient cane in an ordinary working day of twelve to fourteen hours to make 10 piculs (632.5 kilos) of sugar, so that the average mill of Negros may be said to have a daily capacity of from 80 to 100 piculs (5.1 to 6.3 metric tons) of sugar, or approximately 50 to 60 tons of cane.

Feed.—The cane, as it comes from the field in carts or cars, is dumped in the ground near the mill, and then fed into it by hand, an armful at a time. Some mills are provided with mechanical carriers which permit of a rather more even feed and are somewhat easier on the men, as the cane can be fed directly from the ground instead of being carried by hand up to the elevated platform on which the mill stands. As considerable care is required in laying the cane on the carrier evenly and in its manipulation, very little time or labor appears to be saved by this device, and the total number of laborers needed is about the same in each case.

Fuel.—In clear weather, with a properly constructed mill and boiler, the bagasse produced is generally sufficient to supply all the fuel needed, both for grinding and sugar boiling, with some left over for a rainy day. As the bagasse comes out from the mill it is supposed to be picked over by a couple of men stationed there for that purpose, and any unbroken or imperfectly crushed pieces thrown back to be ground over, the thoroughness with which this inspection is made depending largely upon the proximity of the owner or manager of the plantation. As the fresh bagasse contains about 55 per cent of water, it can not be burned directly under the boilers, but must first be dried in the sun, so it is carried out for this purpose in baskets or cradles of bejuco (rattan) slung from bamboo poles, to the plaza, a level space about a hectare in extent surrounding the mill house, and there spread out on the ground and raked over from time to time so as to dry rapidly. At night it is raked up into small piles, then spread out again for a few hours the next morning, when it is usually sufficiently dry either to burn at once or to store in the bagasse sheds for future use. One of the most serious problems the hacendero has to solve is that of always keeping on hand a sufficient supply of dry bagasse to run his mill. In rainy weather this is almost impossible; the surplus stored up in the sheds becomes exhausted in a couple of weeks, and he is compelled either to shut down entirely or to burn wood at a heavy expense; in the meantime the fresh bagasse produced can not be properly dried; and if stored wet it ferments and loses much of its fuel value in consequence.

It is principally for this reason that the planter of the Philippine Islands is so badly hampered by climatic conditions; his field work of planting and harvesting, both carried on at the same time, is largely influenced by the rate at which cane can be received at the mill, and this in turn is dependent upon an ample supply of dry bagasse, so that an unexpected season of wet weather may upset all calculations and cause much damage.

Efficiency of the mills.—In a country where cane is never weighed, and where in many haciendas the empty kerosene case is still the popular unit of volume, it is not surprising that very little is really known about the efficiency of the mills, or the losses in grinding. Bagasse changes in composition so rapidly by evaporation and fermentation that it is almost impossible to transport it any distance to a central laboratory and there determine by analysis its original composition and sugar content. Some reliable figures, of course, can be obtained by establishing a temporary laboratory directly on representative haciendas and making analyses of canes and bagasse on the spot, but even in this way the amount of ground which can be covered in a season is limited. The only really practicable means of determining mill losses accurately and at the same time with reasonable rapidity, in the case of small factories having poor transportation facilities and no chemical control, was found to be the determination of the factor "mill juice in bagasse per 100 fiber," as originally proposed by J. Lely and quoted by Watts.²¹

This factor is of great practical value in that it is independent of the water content of the bagasse, which may be completely dried if necessary and transported a long distance before analysis, when the original weight of mill juice contained per 100 parts fiber can, of course, be calculated from the per cent of fiber and of sucrose in the dried bagasse and the per cent of sucrose in a separate sample of juice from the mill. Strictly speaking, this factor is, from a theoretical point of view, not absolutely correct, a more rigid measure of efficiency of mill work being that given by Deerr²² "as volume of juice in bagasse per unit weight of fiber in bagasse," or

$$\frac{\text{weight of juice in unit weight of bagasse}}{\text{weight of the fiber in unit weight of bagasse} \times \text{density of juice}}$$

a factor which varies only from that proposed by Lely in that it takes into account the specific gravity of the juice. Recent work has proved that, in addition, the efficiency of a mill is also influenced by the quality as well as the quantity of fiber present in the cane, so that absolutely true comparisons between mills working different varieties of cane are hardly possible. The ultimate criterion would be "volume of juice in bagasse per volume of fiber in bagasse," and might be expressed by some such formula as

$$\frac{\text{weight of juice in unit weight of bagasse} \div \text{specific gravity of juice}}{\text{weight of fiber in unit weight of bagasse} \div \text{specific gravity (apparent) of fiber.}}$$

As so little is as yet known concerning the difference in physical properties between different varieties of cane, the analytical determination of such a factor would be impracticable. That canes with a hard, dense fiber do as a rule yield a bagasse containing a lower relative percentage of juice than do those possessing a soft, spongy structure is a fact frequently observed, and one capable of ready demonstration. With dry crushing in mills without hydraulic pressure regulators, the

²¹ *West Indian Bull.* (1908), 9, 85.

²² *Sugar and the Sugar Cane.* Manchester (1905), 107.

common type in Negros, this difference is probably due to the fact that, the distance between rollers being a fixed one, the actual pressure exerted upon the cane as it passes through the mill is determined largely by the hardness of the cane itself and the consequent resistance which it offers to being squeezed out in a thin layer and made to pass through a definite-sized opening. Taking an extreme case as an example, a young cane sprout might flatten out readily and pass between the rollers without having much pressure exerted upon it, while a stick of hard wood of the same size would be subjected to such a severe pressure that it might even break the mill. In a small experimental mill with semi-fixed rollers allowed only a slight "give" by means of rubber washers to the bolts which hold them in place, this varying behavior of different kinds of canes appeared to an exaggerated extent. As a matter of record, while analyzing canes from different parts of Negros, I determined in each case the factor "mill juice per 100 fiber" in the bagasse, in addition to the regular analysis, although theoretically, if this factor is a standard of efficiency for mill work, it should, in the case of the hand mill kept at the same tension, be approximately the same for all kinds of cane. In reality it showed the most extreme variations, always in the same direction; the harder, more fibrous canes tending to yield a bagasse containing a lower percentage of juice than the softer ones, although since the bagasse produced was greater in quantity for the hard canes, the total amount of juice extracted was somewhat less. The following examples indicate the behavior of canes of different fiber content when expressed in the same mill:

No.	Analysis of cane.			Analysis of bagasse.			
	Fiber in cane.	Juice extracted.	Bagasse.*	Fiber.	Sucrose.	"Mill juice,"	"Mill juice" per 100 fiber.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
27	8.05	72.43	27.19	29.62	7.36	65.85	222
29	8.48	72.70	26.90	31.29	9.40	63.19	201
38	9.15	71.23	27.89	32.79	12.47	59.77	182
46	9.89	70.64	28.92	34.19	10.87	56.48	165
44	10.64	70.44	28.85	36.88	9.78	55.22	150
49	11.05	68.38	31.17	35.45	10.99	55.30	156
30	11.80	68.49	30.89	38.20	9.83	56.03	147
45	12.61	67.18	32.20	39.17	9.97	50.52	129
41	14.07	67.52	31.61	44.52	8.44	43.99	99
47	14.63	65.24	34.18	42.83	7.91	43.37	101
40	15.48	65.12	33.63	46.02	7.32	48.54	105

* The slight difference between the sum of juice and bagasse and 100 is due to the loss of water by evaporation from bagasse while preparing it for analysis. This was taken into consideration in calculating the percentage composition of the cane as given previously, but is not essential here.

Watts²³ gives a table showing the approximate result with different kinds of mills:

Type of milling plant.	Juice per 100 fiber of bagasse.
Bad single mill-----	200
Fair single mill-----	180
Good single mill-----	150
Cane splitter and single mill-----	130
Krajewski and two 3-roller mills with mac- eration-----	70
Krajewski and three 3-roller mills with mac- eration-----	30
Krajewski and three 3-roller mills with mac- eration, best work-----	25

According to the above, the hand mill used in making analyses of Negros canes would when working very juicy and tender canes be considered about as efficient as a very poor, single 3-roller mill, whereas with canes containing 14 or 15 per cent of fiber it would be said to approximate in power the work of two 3-roller mills and crusher, without maceration. The differences obtained in actual practice among 3-roller mills are by no means so great, but there is, as will be shown later, a decided variation in the efficiency, calculated according to this factor, of the same mill when working canes of different fiber content, so that the quotient "mill juice per 100 fiber in bagasse," can not be accepted without question as an absolute standard of efficiency of mill work, regardless of the kind of cane ground. Given about the same composition of cane, it is of some value in determining the comparative efficiency of mills in the same neighborhood, and, in conjunction with complete analyses of the canes ground, affords a ready method for ascertaining the per cent of total sugar lost in bagasse by muscavado mills.

The results of a number of determinations made on different mills in Negros are here given. The usual method of procedure in taking samples and preparing them for analysis was as follows:

Samples, consisting of a few handfuls at a time of the bagasse as it came from the mill, were taken at intervals of five or ten minutes and placed to dry in a large coarse sack laid directly on top of the uncovered portion of the engine boiler. At the same time four or five samples of 5 cubic centimeters each of juice were taken directly from the mill bed and put in a liter bottle containing 0.2 gram mercuric chloride. Sampling was continued thus for three or four hours until both bottle and sack were full; the bagasse was then, as a rule, allowed to remain for a few hours longer, while field samples of soil and cane were being taken, by which time it was sufficiently dry to allow of its being transported a considerable distance back to the laboratory. On arrival at the temporary laboratory headquarters, the bagasse was either analyzed at once or spread out over the boiler there to keep dry until morning. The whole sackful was spread out on a clean floor and chopped into coarse pieces, then quartered down to a final weight of about half a kilo, which was chopped much finer and used for analysis. The work of taking the original samples at the mill was all done

²³ *West Indian Bull.* (1909), 10, 109.

by a trained native assistant, with the idea of disturbing as little as possible the ordinary routine of mill work, this point being of considerable importance in securing representative samples, since the efficiency of a single mill depends much upon the care with which poorly crushed pieces of bagasse are thrown back to be reground, and native laborers are prone to be somewhat too attentive to duty if they imagine their work is being inspected by a foreigner.

"Mill juice per 100 fiber" in the bagasse from various mills in Negros.

No.	District and hacienda.	Horse-power of mill.	Mill juice per 100 fiber.
PONTEVEDRA—LA CARLOTA.			
1	Carmencita (first test) -----	12	168
2	Carmencita (second test) -----		155
3	Carmencita (third test) -----		197
4	Carmen -----	24	142
5	Esperanza -----	16	170
6	Najalin -----	12	149
BAGO.			
7	Lumanġub -----	12	161
8	Malingin -----	12	197
9	Lumanġub -----	12	157
10	Do -----		161
11	Santo Domingo -----	8	168
13	San Juan del Monte -----	6	220
ILOG CABANCALAN.			
14	San Isidro -----	16	201
15	San Jose -----	10	193
16	Soledad -----	6	207
17	San Juan -----	16	236
18	San Luis -----	6	217
SAN CARLOS.			
19	San Jose -----	12	169
20	Providencia -----	8	151
21	Refugio -----	10	151
22	Fortuna -----	12	216
23	Valle Hermoso -----	10	159
Average -----			178.5

^a Complete analysis=sucrose, 8.62; fiber, 34.7; moisture, 54.4.

^b 5-Roller mill.

^c 3-roller mill.

^d Built 1889 by A. W. Smith, Glasgow; rollers, 36 by 24 inches.

^e 5 samples taken at five-minute intervals and analyzed at once. Complete analysis=sucrose, 10.51; fiber, 34.35; moisture, 55.14.

^f 10 samples during afternoon (bagasse dried over boilers and analyzed next day).

^g Built by Aitken, McNeil & Co., 1882.

^h Built by A. W. Smith, 1871; rollers, 16 by 24 inches.

ⁱ Complete analysis=sucrose, 12.02; fiber, 33.60; moisture, 54.38.

^j Rollers, 22 by 42 inches.

^k Rollers, 18 by 36 inches.

The extent to which the same mill may vary at different times is shown by the first three tests. Numbers 9 and 10, taken on the same day, indicate that as long as a mill is working the same kind of cane fairly concordant results may be obtained, also that bagasse may safely be dried and preserved, at least for a short time, without changing in

composition. It was found that with bagasse dried down to a water content of 10 or 15 per cent very little trouble was caused by fermentation, even if it was kept for several days; if not so dry it deteriorates quite rapidly.

For example, number 13, from a small and rather weak mill, on first analysis yielded a factor of only 162, owing to the fact that the sample was taken late in the afternoon, had to be carried back to the laboratory in a partially dried condition, and was left thus overnight without further drying owing to a temporary shut down in the mill and no steam in the boiler. When analyzed it still contained about 35 per cent of water. As this bagasse was so evidently poorly crushed, it was necessary to make another test of the mill and analyze the bagasse immediately, with the result, as shown in the table, of 220.

The average of all the mills tested shows that 178.5 parts of mill juice are lost in bagasse for every 100 parts of fiber in the bagasse, or, since all the fiber of the cane finally goes into the bagasse, 178.5 parts of mill juice are lost in bagasse for every 100 parts of fiber in the cane, this figure corresponding to what Watts gives as the working of a "fair single mill." From these data it is easy to calculate the percentage of juice (or of sucrose) lost in crushing by the average mill in Negros.

The average composition of the cane of the island has already been stated as sucrose, 16.06 per cent; fiber, 10.02 per cent, with a juice containing sucrose, 18.40 per cent when expressed by a hand mill; therefore the make up of the cane is, approximately, fiber, 10.02; juice, 87.28; water other than juice, 2.70—assuming the residual juice to be of the same composition as that first expressed. Since there are 178.5 parts of juice in bagasse for every 100 parts of fiber present, there would be lost, if perfectly clean cane of the above composition were ground, 17.88 parts juice from every 100 parts cane containing 10.02 parts fiber and 87.28 parts juice.

In other words, the "extraction" of juice in per cent on the cane would be 69.40 out of a possible 87.28, or the per cent of total juice (or of total sugar) loss in milling would be $\frac{17.88}{87.28} = 20.48$ per cent.

It is very doubtful if as good results as this are ever secured in actual practice, for the following reason:

To bring in cane from the fields absolutely free from trash and adhering leaves requires considerable extra care and attention, which ordinary laborers can not be depended on the exert; moreover, cane is much easier to carry on the shoulder if cushioned and held together by a few extra leaves, and packs more easily in the wagons without slipping out of place, so that the cane carts usually come into the factory laden with a goodly amount of dirt, dead leaves, and other trash. A careful manager will see that the greater part of this is removed before it enters the mill, but very often up to 3 per cent or more of the weight of the cane will enter the mill dry, and come out wet with juice.

Most planters do not seem to realize the loss which this practice entails, since, judged by the eye alone, a few leaves more or less are of little importance. In some lots of cane, which had been if any-

thing a little more carefully cleaned than is customary, it was found that 500 kilos of cane about to enter the mill carried with it 12.5 kilos of dry trash. Assuming that on the average 2 parts of fiber will be introduced into the mill with every 100 parts of clean cane, we can calculate the effect produced on the composition of the cane and the results obtained in milling as given above.

The cane as ground will then contain $\frac{12.02}{102} = 11.79$ per cent fiber; $\frac{87.28}{102} = 85.56$ per cent juice, and $\frac{2.70}{102} = 2.65$ per cent water other than juice, and the loss of juice in bagasse will be $178.5 \times 0.1179 = 21.05$ per cent on the cane, leaving an extraction of 64.51 out of a possible 85.56, and a loss in per cent on the total sugar (or total juice) of $\frac{21.05}{85.56} = 24.60$.

In grinding a very hard cane, such as the black variety grown to some extent in San Carlos, the losses would be greatly increased.

Sample number 41, for instance, shows on analysis, fiber, 14.07 per cent; sucrose, 15.02 per cent; and sucrose in juice, 19.18, corresponding to a juice content of 81.43 per cent. Addition of 2 per cent fiber as trash would make the cane as ground contain 15.75 per cent fiber and 79.84 per cent juice. Assuming the average mill efficiency, there would be lost per 100 parts cane $178.5 \times 0.1575 = 28.11$ parts juice, giving an extraction of only 51.73 out of a possible 79.84 per cent and a loss in per cent of total sugar of 35.22.

In round numbers, then, it may be stated that the average planter of Negros loses in bagasse about 25 per cent of the total sugar present in the cane. In extreme cases, with very soft and tender cane, this may fall as low as 20 per cent, and when grinding very fibrous cane it may rise as high as 33 per cent. The extraction of juice on the weight of the cane may range from 50 to 70 per cent, but averages about 64.5 per cent. Therefore from 100 tons of cane there are obtained 64.5 tons of juice. This is rather better than the results obtained in most countries where sugar is produced by primitive methods (Watts²⁴ states that in Barbados the crushing ranges from 53 to 60 per cent), but should be attributed not to any superior efficiency of the mill in Negros, but solely to the free-milling qualities of the cane grown here.

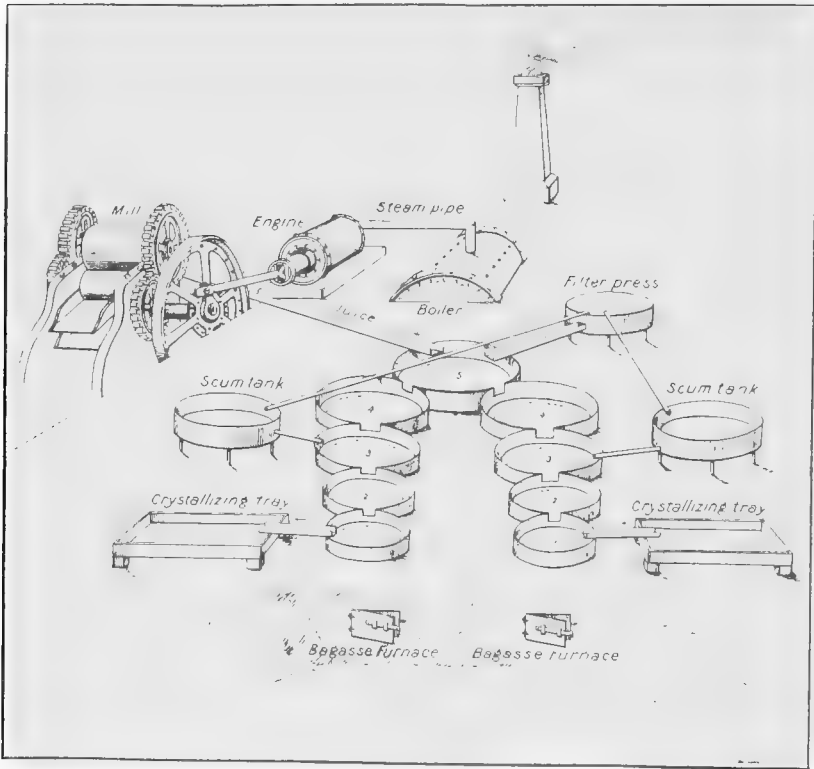
MANUFACTURE OF SUGAR FROM THE JUICE.

Arrangement of the sugar house.—The sugar-boiling plants of Negros consist essentially of a battery of hemispherical iron vessels or "cauas," usually five or six in series, in which all the operations of tempering, clarifying, concentrating the juice, and boiling the resultant sirup to a concrete are performed.

The "cauas, which may be anywhere from 40 to 80 inches (1 to 2 meters) in internal diameter, measured from a short distance below the top, where the

²⁴ *Loc. cit.*

sides spread out to form a sort of lip, are built into the top of a brick or stone furnace with only their lips or rims projecting above the surface, in such a fashion that they extend in a direct line, ascending slightly in elevation from the largest, where the juice enters from the mill, to the smallest, or "caua mayor," also called "caua de puntos," in which the final operation of boiling the sirup to a "massecuite" is carried out. To prevent loss of the juice by boiling over, the whole battery is built up along the sides and inclosed by a protecting wall of brick or cement, 40 or 50 centimeters high, or an extra perpendicular rim of thin iron may be attached to the top of each "caua." The accompanying schematic diagram gives a good idea of the most customary arrangement of a sugar house.



There are really two distinct batteries built over separate furnaces, having only the No. 5, or juice-receiving, "caua" in common. (The "cauas" are ordinarily numbered in an opposite direction to that in which the juice proceeds in the course of manufacture, No. 1 always being the one where the final boiling is done.) The two batteries are fired through the furnace doors close under the No. 1 "caua" in order that the heat may be most intense and easily controlled at this point, and either side may be used independently of the other if desired, while by placing a multitubular boiler directly back of No. 5, where the two furnace chambers converge into one, sufficient steam to run the engine may be generated from the heat of the waste furnace gases, without the use of extra fuel, although of course a separate firing door for the boiler and a by-pass to lead the heat from the battery directly up the chimney, if necessary, must be provided, so that either grinding or boiling may be carried on independently.

Clarification of the juice.—The freshly expressed juice flows from the mill bed through an open wooden trough, generally being strained through a cloth or wire screen to remove suspended particles of bagasse, etc., into "caua" No. 5, where it is warmed up to 70° or 80° and some of the lighter impurities rise to the surface in the form of a froth, which is skimmed off and thrown into the scum tanks on the side. From time to time, as it is required, juice is ladled with a kerosene tin fixed to the end of a wooden pole from No. 5 to the smaller "cauas" No. 4 on either side, the idea being to keep them so nearly full that scums rising to the surface here will again tend to flow back into No. 5.

Liming.—Lime is generally added in two stages, the juice being about half neutralized in No. 4 and tempering completed in No. 3, where the first violent ebullition occurs; sometimes a handful or so will be thrown into No. 5, and if the "maestro" is in doubt as to the amount required, he may even correct an under-limed juice by adding lime a little at a time up as far as No. 2, or, very rarely, even in the "caua de puntos." This process of defecation, is always under the personal charge of the "maestro de azúcar," or chief sugar boiler, a native of many years' experience, who may receive as high as a peso a day for his services. The process is the following: About half a coconut shell full of dry lime (half a kilo) is thrown into a ladle, which is then half filled with hot juice, and, after a few seconds' shaking to promote solution, emptied slowly into the "caua," leaving most of the undissolved lime at the bottom of the ladle, which is refilled with hot juice and poured out again in a similar manner, until only the larger pieces of undissolved lime, about a third of the whole, remain as a residue; these are then thrown into the scum tanks.

Since a brighter colored, although less clean, sugar is thus produced, the tendency among the "maestros" is toward under, rather than over, liming, leaving a juice still very slightly acid to litmus.²⁵ A good "maestro" knows by instinct, bred of long practice, just when the juice is properly tempered, he judging largely by the peculiar alkaline odor given off as the neutral point is approached, and also by the appearance of the juice when poured out in a thin stream, it changing in color from a dark olive brown to a somewhat lighter, yellowish tinge when sufficient lime has been added. As the limed juice in No. 3 begins to boil, the impurities are coagulated, rise to the surface, and overflow into No. 4 and sometimes into No. 5, where they are skimmed off and thrown into the scum tanks.

This process of surface clarification is continued in No. 2, which is in reality almost a part of No. 3, juice overflowing from one to the other and being ladled back again intermittently, becoming cleaner and more concentrated all the time.

The lime used comes chiefly from the neighboring island of Guimaras, and is of execrable quality. It is invariably slaked directly after burning, some kilns, it is said, even using sea water for this purpose, and is stored and shipped either in bulk or in bags or "bayones" of "buri" leaf such as are used for packing sugar, so that by the time it has reached Negros it has had an excellent opportunity to become converted into the carbonate, which is practically useless for clarification. According to Geerligs²⁶ lime used for clarification should fill the following specifications:

"When mixed with half its own weight of water it should become very hot within a few minutes. The slaked lime after the addition of ten times its weight of water should form a soft cream, which on being passed through a fine sieve should not leave behind more unslaked particles than one-tenth of the original

²⁵ Litmus paper, by the way, is still a decided curiosity in Negros, and as far as I know there is not a sugar maker in the entire island who regularly makes use of this or any other indicator as an aid in defecation.

²⁶ Cane Sugar and its Manufacture. Manchester (1909), 160.

weight, and most of these particles should become soft after an hour's standing in a moist condition. The lime, after being slaked, should dissolve in hydrochloric acid without appreciable effervescence and not leave more than 2 per cent insoluble matter. The maximum percentages of impurities should be:

	Per cent.
Iron oxide and alumina.....	2
Sulphuric acid	0.50
Magnesia	2
Silica	2
Carbonic acid	2
Moisture	2

A sample of the lime used in Negros as tested there was found to contain about 50 per cent of hard lumps, which would not soften when mixed with water. On treating it with dilute hydrochloric acid, the greater portion of it dissolved, although very slowly, and with much effervescence. A sample was bottled and sent to the Bureau of Science, Manila, where it was analyzed by Mr. L. A. Salinger:

	Per cent.
Loss on ignition	36.81
Iron oxide and alumina.....	1.39
Magnesia	8.35
Silica	1.42
Calcium oxide	51.42
Total	99.39
Carbonic acid	10.81

Its high percentage of magnesia alone should cause it to be rejected. Subtracting from the total lime that portion present as the carbonate leaves only 37.66 per cent of calcium oxide, as such, in the mixture, and a large proportion of this is in such hard lumps as to be unavailable for clarification. From the standpoint of economy, a fairly pure quicklime would be cheaper at three times the price.

Boiling to a concrete.—When a “cocida” or strike of “massecuite” has been taken out of the “caua mayor,” the latter is refilled as quickly as possible (a few minutes’ delay might cause the kettle to become overheated and crack) with sirup from No. 2, which by this time has become fairly clear and has been concentrated to about 50° Brix; fresh bagasse is thrown on the fire, and in a short time the pot begins to boil furiously. As the sirup evaporates it is replenished from No. 2, and any last, remaining, flocculent impurities rising to the surface are swept back into the latter. When the “maestro” decides that sufficient sirup has been taken in to yield a “cocida” of the desired size—from 100 to 300 kilos of sugar are taken out at a time—he declares No. 1 “caua” closed, and no further additions are made to it, but the whole mass is boiled down as rapidly as possible until a small sample taken with a stick shows it to be of the proper consistency to take out. At this point the fires are drawn and the “massecuite” poured out into wooden trays, termed “enfriaderas,” where it is “crystallized in motion” by stirring with a spade. The time required for crystallization depends much upon the kind of sugar produced, and an experienced sugar maker can, from the behavior of the “massecuite” in the “enfriaderas,” form a pretty accurate opinion of the quality of sugar which is being turned out. A high-grade “massecuite” will begin to boil up almost as soon as it strikes the cooling trays, and will subside quickly, only to rise up again in a minute or so. If this rising and falling is very energetic and occurs two or three times in quick succession, it is

a sign of a good "No. 1" sugar, which will be completely dry inside of fifteen or twenty minutes.

The phenomenon is very probably caused by the large amount of heat suddenly liberated, as a part of the sugar crystallizes from its supersaturated solution on striking the cold boards. This might bring about a partial solution of some of the sugar, but as the mixture is stirred and grows cooler more water is evaporated, and other sudden crystallizations take place. "No. 3" sugar will only rise up in the "massecuite" once, and takes a longer time and more stirring to crystallize properly, while low-grade "corriente" simply spreads out in a thin layer like molasses, and may need to be stirred for an hour or more before it shows any signs of crystallization.

Local names for juice, sirup, and the sugar derived from them in various stages of manufacture.—The native sugar boilers have a rather complete nomenclature for the different juices and sirups during the process of manufacture, no less than eleven distinct stages being recognized from the raw juice to the finished product. These are:

1. *Intus*: The raw juice as it comes from the mill.
2. *Laso*: Juice which has been boiled and clarified.
3. *Almibar*: The thin sirup in the No. 2 "caua."
4. *Pulut*: Thick sirup, the first stage of concentration in the "caua de puntos" (literally, "kettle of stages").
5. *Pulut gabotón*: A very thick sirup which sticks to or tends to pull out the teeth when eaten ("gabotón"=to pull out).
6. *Pasagi*: At this stage a sample removed and cooled in water can be molded and will just hold its shape. The sirup sometimes tends to boil over at about this point, in which case 20 or 30 cubic centimeters of coconut oil, or an emulsion made by squeezing out fresh coconut meat, are added, which lessens the violence of the boiling, and, at the same time is said to prevent the mass from sticking to the bottom of the kettle and burning.
7. *Batok*: A small sample of the sirup cooled in water and formed into a sharp-pointed cone will penetrate a stalk of cane brought down with force upon it.
8. *Butum*: A sample when cooled can be pulled out into a thread without breaking. Sometimes a native "taffy" candy, termed "butum-butum," is made from a portion of the sirup which has arrived at this stage ("butum"=to pull).
9. *Bali*: A sample dropped into cold water becomes somewhat brittle, so that a fine thread will break sharply without much bending. The "massecuite" is generally taken out at this stage ("bali"=to break).
10. *Polvos*: The fine threads, cooled as above, are very brittle and break like glass. This stage is reached only when very good, dry sugar is being made. Sugar from an impure juice will begin to stick to the "caua" before this point is reached.
11. *Calamay*: Sugar, the finished product.

Losses during boiling.—Since no molasses is produced in Negros, the clarified juice being boiled directly to a concrete, the calculation of losses of sucrose incurred is somewhat simplified, and a factory control would be a comparatively easy matter were it not for the fact that nowhere in the Island is any record kept of the weight of canes entering the mill, or the weight or volume of juice boiled, nor are any large scales or other facilities available for accurately determining these rather necessary figures. Losses during the boiling-down process may result from—

(1) Sucrose thrown away with the skimmings from the different "cauas," settlings from the clarifying tanks, and filter-press mud. (2) Sucrose inverted by prolonged boiling at ordinary atmospheric pressure, as indicated by an increased ratio of reducing sugar to sucrose in the final product over that found

in the original juice. (3) Sucrose burned or caramelized during manufacture, together with that first inverted and then completely destroyed by the combined action of lime, lime salts, and excessively high temperatures. (4) Mechanical losses, including juice, sirup, and "massecuite" spilled in the handling, and sugar spilled, stolen, or eaten by the workmen.

Scums.—The per cent of sucrose in the scums, etc., which are thrown away, is always very high, since the juice adhering to these has, by the time clarification is completed, become much more concentrated than the original, raw liquid. A few representative analyses of these waste products will serve to show the considerable amount of sugar which may be carried away by them:

Skimmings from unlimed mill juice in a preliminary clarifying tank.—These consist largely of fine particles of bagasse, mixed with froth and juice, which are thrown into a basket suspended over the tank and allowed to drain without pressure, then thrown away. The sample contained 25.2 per cent total solids and 17.9 per cent sucrose.

Skimmings from caña No. 5, which were not considered worth pressing, but were thrown away at once, contained 29.3 per cent of total dry substance and 22.8 per cent sucrose.

Filter-press mud. In this instance a large receptacle located between "cañas" No. 4 and No. 3 served as a sort of settling tank, being filled with hot, partially limed juice from No. 4, which after settling for an hour or so was decanted into No. 3. As in the meantime unclarified juice was continuously being ladled directly from No. 4 to No. 3, the advantages of the system are not obvious. The settlings from this tank, about one-fourth its total volume, were run into sacks, on top of which were placed pieces of old iron, car wheels, etc., and the whole allowed to drain for half a day until it had nearly stopped dripping, when the sacks were emptied of the remaining sludge, which was thrown away. A sample of this sludge was found to contain 23.2 per cent sucrose.

Of course, there are some few factories in Negros where such large losses are not incurred, but the instances cited above represent rather better working than the average, many places allowing scums and settlings to run to waste directly, without any attempt at filtration.

There are two or three fairly modern, steam-heated filter presses on the Island, but they do not appear to have given universal satisfaction, principally because of the lack of intelligent labor to operate them, and the consequent trouble due to leaks, broken filter cloths, etc. A very simple, and yet fairly efficient form of scum filter found working in the district of Bais consists of a square wooden box of a little over a cubic meter capacity, provided with a perforated double bottom and a plunger at the top, forced down by a very heavy screw. The scums are filled into ordinary flour sacks, which are tied up tightly and piled inside the box; pressure is then brought to bear, at first slightly, but finally with much force, so that the resulting cake is said to come out almost as dry as ordinary filter-press cake. About one hour is required to fill this press, and two and a half hours to empty it, about four presses full, or 4 tons of scums, being treated per day. A fully half of this, containing at least 20 per cent of sucrose, would otherwise be thrown away, the press causes a saving of about 400 kilos of sucrose, or, at the present price of sugar, about 50 pesos per day. The whole affair cost less than 200 pesos to make, including 150 pesos paid for the screw, and, considering the class of labor available for working it, is probably about as efficient for a small factory as the more costly modern filter presses.

Inversion losses.—With a view of determining the losses occasioned by the conversion of sucrose into reducing sugars, tests were made at two haciendas of the juices and sirups in the various "cañas" covering periods of about half a day each:

SUGAR-BOILING TEST, HACIENDA CARMENCITA, PONTEVEDRA (FEBRUARY 9, 1909).

The equipment consists of two sets of "cauas," six in a series, worked independently, and two large clarifying tanks, which in reality serve more as storage tanks, since very little clarification takes place in them, and the raw juice is often run directly from the mill to the "cauas" without entering the tanks at all. Ordinarily, the juice is pumped from the mill bed to these tanks, where it stays from fifteen to thirty minutes, and is heated by exhaust steam to about 60°, some of the lighter impurities in the meantime rising to the surface and being skimmed off. The warmed juice flows by gravity from the tanks into "caua" No. 6, and when this is full overflows into No. 5, where it remains some fifteen minutes before liming. Juice begins to boil in Nos. 3 and 4, which soon boil over, and the scums are swept back into No. 5, there to be skimmed off and thrown into a scum tank. Aside from these details, the procedure is the same as that previously described. As it is only a semicontinuous process, juice being periodically ladled from one kettle to another as each "cocida" is taken out and "caua" No. 1 emptied, an attempt was made to follow the course of one lot of juice, taking samples each time it was transferred from one "caua" to the other throughout the series. It was found impossible to do this absolutely, since the juice in each "caua" is always more or less mixed with that boiling back from the one in front or ladled in from the one behind it. As canes from the same field were being ground, the mill juice was fairly constant, so that but little variation can be attributed to this factor.

Sample.	Reaction to litmus.	Brix.	Sucrose (direct polarization).	Quotient of purity (apparent).	Reducing sugar.	Reducing sugar per 100 sucrose.
Raw mill juice in clarifying tank	Acid	18.63	15.92	90.84	0.86	5.08
Juice warmed to 60° C. as it enters "caua" No. 6 (almost the same as first sample)	do	18.64	16.83	90.28	0.91	5.40
Juice which overflows from No. 6 to No. 5; sample taken after No. 5 had been filled, but before liming	do	18.89	16.90	89.41	0.93	5.50
Lined juice as it enters No. 1	Very slightly alkaline.	19.39	17.30	89.23	0.89	5.14
Partially clarified juice entering No. 3	Neutral	30.74	27.26	88.69	1.56	5.72
Clarified juice entering No. 2	do	34.92	31.04	88.92	1.83	5.89
Clear sirup entering No. 1	do	55.04	49.16	89.33	2.86	5.82
Sugar produced	do		86.71		5.9	6.8

A barely perceptible inversion apparently took place as long as the raw juice was being heated without liming, as shown by the increase of reducing sugars over sucrose. The excess of lime in the fourth sample evidently had a slightly destructive action on the invert sugars formed, since their ratio to sucrose drops a trifle. From here on it increases slowly, but the final ratio in the sugar produced is only 1.7 per cent higher than that of the original juice, so that very little loss can be traced directly to inversion, as shown by the reducing sugar ratio. The probabilities are that very much more inversion has actually taken place than is here indicated, but that, owing to the well-known destructive action of lime salts on glucose and fructose at high temperatures, these products have been immediately decomposed into carbonic, formic, and acetic acids, etc., and hence can not be detected by analysis. The apparent purity of the juice falls slowly, down to the

last two samples, where it has become almost completely clarified, and where it rises slightly; the difference is so small, especially at the higher concentrations—a difference of 1° in purity here would be caused by a difference of 0.2° in the Brix of the diluted (1 to 4) sirup—that it might almost be caused by experimental error.

SUGAR-BOILING TEST, HACIENDA LUMAÑCUB, BAGO (MARCH 4, 1909).

The boiling pans here are arranged in the customary manner in two parallel series of four "cauas" each, having a large No. 5 in common. The mill juice falls first into a preliminary clarifier or juice warmer, consisting of a rectangular tank set over the furnace, just back of "caua" No. 5, and provided with wooden partitions at the top and bottom, leaving only a narrow slit in the center for the mill juice to pass through, so that some of the lighter impurities can be removed as scums from the top, while much of the heavy dirt settles to the bottom. Stopcocks at the farther end of the tank permit juice to be drawn off at two levels. As the juice only remains here a few minutes, is only heated to about 65° and not limed, no real clarification can take place, but the arrangement seems to be of some value in mechanically removing sand and dirt and fine particles of bagasse. Lime is first introduced in "caua" No. 5, and augmented, if necessary, in Nos. 4 and 3. Juice begins to boil in No. 3, and at times in No. 4. Samples were taken from the various "cauas" of the hot "massecuite" as it was ladled out from the "caua mayor," and also of the sugar made, every time a "cocida" was taken out during the course of the afternoon. In this experiment no attempt was made to follow the course of any one particular lot of juice, but I desired rather to determine the average composition of the juice and sirups in the different kettles. Cane from the same field was being ground during the entire day and the mill juice was of practically uniform composition throughout the test. The mixed samples analyzed as follows:

Sample	Reaction to litmus.	Brix.	Sucrose (direct polarization).	Quotient of purity (apparent)	Reducing sugar.	Reducing sugar per 100 sucrose.
Raw mill juice as it enters preliminary clarifiers	Acid	20.95	19.73	94.21	0.38	1.92
Mill juice flowing from clarifier into "caua" No. 5	do	21.33	20.03	93.89	0.39	1.94
Limed juice from No. 5 as it is ladled into No. 4	Slightly alkaline.	25.68	23.47	91.41	0.49	2.08
Limed and partially clarified juice from No. 4 as it is ladled into No. 3	do	30.12	27.38	90.86	0.74	2.70
Clarified juice from No. 3 as it enters No. 2	do	30.82	28.06	91.05	0.75	2.27
Clear sirup from No. 2 as it enters No. 1	Neutral	44.16	40.86	92.53	1.01	2.05
"Massecuite" from No. 1 as it is poured into the "enfriadera" (diluted to approximate Brix of mill juice (1-4) and analyzed as such)	do	95.08	88.16	92.72	3.04	3.46
"Massecuite," analyzed as sugar		*94.40	88.39	93.63	3.04	3.44
Sugar after crystallizing and cooling		*97.32	90.59	93.09	3.37	3.72

* Total solids by drying.

As in the previous test, only a slight inversion can be detected up to the time the juice is fully limed; here the formation of reducing sugars seems to continue to some extent, even with an alkaline reaction to litmus in "caua" No. 4, but, owing to the destructive effect of the lime, the "glucose" ratio diminishes again from this point on until the final boiling takes place in No. 1, where it is much increased.

Since reducing sugars are so easily decomposed at the temperatures which must exist during this final boiling, it is impossible to determine just how much inversion does take place at this stage of the process, but it must be considerable in amount, as the proportion of reducing sugar to sucrose is always decidedly larger on leaving than on entering this "caua," and the increase continues even while the hot "massecuite" is being crystallized in the "enfriaderas." The purity of the juice diminishes gradually during the first heating until clarification is nearly complete, when it again increases. The purity of the last two samples, calculated on the percentage of total solids obtained by drying in an oven to nearly constant weight, is naturally higher than that of the previous ones which were figured on degrees Brix; the difference here is less marked than is generally noted in massecuites from modern sugar factories, the reason probably being that low-grade sugars of the open-kettle type always carry a certain percentage of insoluble impurities such as sand, dirt, bits of bagasse, etc., which raise the true total solids of the "massecuite" without affecting its specific gravity, thus counteracting in a measure the high Brix readings caused by salts in solution.

From the above tests it is clear that, even with the old open-kettle process of sugar boiling, there is comparatively little loss to be feared by inversion while evaporating the juice down to a density of 50° or 60° Brix, preliminary to the real sugar boiling which takes place in "caua" No. 1, provided reasonable care is taken in liming so as to have the juice either neutral, or very slightly alkaline or acid. This is what might be expected theoretically, since this first evaporation, corresponding approximately to that carried on in modern works in the multiple effects, is seldom carried further than a density of 55° Brix, and even at atmospheric pressure the boiling point of a sugar solution of this concentration is not very high.

Gerlach²⁷ determined the boiling point of aqueous sugar solutions as follows:

Sucrose.	Tempera- ture.
<i>Per cent.</i>	<i>°C.</i>
10	100.4
20	100.6
30	101.0
40	101.5
50	102.0
60	103.0
70	106.5
80	112.0
90.8	130.0

For the purpose of calculation, it may be assumed that the juice is heated in "cauas" Nos. 5, 4, 3, and 2 for a period of four hours, and has during that time an average sugar content of 30 per cent. Herzfeld,²⁸ working with very slightly alkaline solutions of pure sucrose, found that in one hour the percentage loss by

²⁷ *Z. Ver. Zuckerind.* 13, 283.

²⁸ *Z. Ver. Zuckerind.* 43, 745.

inversion in a 30 per cent solution at 100° was 0.0423, and at 110°, 0.0557. Assuming that the impurities in a cane juice raise the boiling point up to even 105°, during the four hours, there would only be lost about 0.2 per cent of total sucrose by inversion. Local overheating of the pans, and boiling the juice before it is completely neutralized, will raise this figure somewhat, but it may be safely stated that ordinarily less than 1 per cent of sugar is lost by inversion prior to boiling down in the "caua mayor."

Sucrose burned in manufacture.—While sugar solutions of moderate concentration may be heated for a long time with little loss, when they are highly concentrated a much more rapid inversion takes place. Eckleben²⁰ found that an 85 per cent sugar solution heated in a closed vessel at 120° to 125° was completely inverted in six hours. The "massecuite" from the No. 1 "caua," since it contains as a rule only from 5 to 10 per cent of water, must attain a temperature of from 120° to 130° during the last stages of concentration, and owing to imperfect circulation and conduction of heat in such a thick solution, the temperature of that portion in immediate contact with the sides of the kettle is necessarily much higher. As has been previously explained, only a small percentage of the total inversion occurring here can be determined analytically, since the invert sugar formed is rapidly decomposed at this high temperature.

Probably the largest losses incurred in the process of manufacture take place in the "caua mayor" during the last fifteen or twenty minutes' boiling of each "cocida," and the longer it is necessary to keep the "massecuite" in this pan the greater becomes the loss. A "massecuite" of high purity can be concentrated rapidly without so much danger of sticking to the pan and burning, since sucrose is more soluble in the water of such a "massecuite" than of one containing more impurities²⁰ consequently it remains in solution longer and boils more uniformly.

An impure sirup, during the first half of its evaporation in the final kettle, may appear as light colored as any other, but, as it becomes thicker and hotter, decomposition of the invert sugar begins, giving rise to dark-colored products, some of which, probably, being of an acid nature, cause still more inversion of sucrose. Sometimes a "cocida" will boil along very smoothly for a time, then suddenly turn dark and begin to stick to the pan, at times bumping with sufficient violence to scatter hot "massecuite" clear out of the pan. In such cases any attempt at further concentration is generally useless, as the sugar decomposes rapidly, often giving off smoke and acrid vapors, and it can never be made to crystallize properly. Boiling too much "massecuite" at one cooking, poorly arranged "cauas," inefficient firing, poor fuel, in fact anything which prolongs the stay of the "massecuite" in the first kettle, increases the loss by burning. This fact is well appreciated by the planters in general, who say that it is very difficult to produce good sugar in rainy weather, even from excellent cane, since the bagasse can not be sufficiently dried to give a hot fire.

Mechanical losses.—These are, of course, impossible to determine separately. They will be estimated together with those due to burning in manufacture in the calculation of the percentage yield from the cane, which is given in a subsequent portion of this paper.

²⁰ Z. Ver. Zuckerind. 40, 817.

²⁰ Goerlitz, Cane Sugar and its Manufacture. Manchester (1909), 225.

QUALITY OF SUGAR PRODUCED IN NEGROS.

Negros sugar, as sold in the Iloilo market, is classified commercially under two main headings, "Superior" and "Wet," according to whether it polarizes above or below 80°.

The "Superior" sugar is subdivided as follows:

No. 1, from 88°.9 (or higher) to 87°, inclusive, average, 88°.

No. 2, from 86°.9 to 85°, inclusive, average, 86°.

No. 3, from 84°.9 to 80°, inclusive, average, 82°.5.

The difference in price between grades has ordinarily been 25 centavos per picul of 63.25 kilos. The fact that practically all Iloilo "Superior" sugar is now bought for shipment to New York is of late beginning to disturb this simple and harmonious price difference between grades. According to the New York basis of 0.1 cent gold per pound for each degree difference in polarization up or down, the difference in price between Nos. 1 and 2 would be 56 centavos per picul, and between Nos. 2 and 3, 98 centavos per picul. Large purchases of "Superior" sugar are generally based on an arbitrary assortment, originally supposed to represent the average proportion of the different grades produced, which is one-eighth (or 12.5 per cent) of No. 1, two-eighths (or 25 per cent) of No. 2, and five-eighths (or 62.5 per cent) of No. 3, the price for assorted being half-way between No. 2 and No. 3, and its average polarization being 84°. Of late years rather more No. 1 has been produced and less of Nos. 2 and 3 than is called for by "basis assorted," although the average polarization is about the same. The records of "Superior" sugar received by one firm during five years were: No. 1, 26 per cent; No. 2, 18 per cent; and No. 3, 56 per cent—the average polarization of the lot coming to 84.4 per cent.

Sugar polarizing less than 80° is classed as:

"Humedo" (wet), from 79°.9 to 76°, inclusive.

"Corriente" (current), from 75°.9 to 70°, inclusive.

"Humedo" is quoted at about 1 peso less than No. 3, while "corriente" has no fixed ratio to the other grades. The relative amounts which are produced of these two grades are rather difficult to estimate, since much is mixed together and sold to Chinese buyers as "wet" sugar regardless of its polarization, while the better grade of "humedo" is frequently worked off by blending it in small quantities with No. 3 "Superior." Climatic conditions during different years also affect the proportion of low-grade sugars turned out, but they rarely exceed 20 per cent or fall below 10 per cent of the total production.

The average quality of the sugar produced in Negros from year to year may be considered, then, to be approximately 85 per cent of "Superior," polarizing 84°, and 15 per cent of "Wet," polarizing 75°, with an average polarization for the whole of 82°.6.

Quality of sugar estimated from tests made in Negros.—In connection with the work of testing the efficiency of mills, samples of mill juice and of the sugar being made at the time were analyzed as follows:

Table showing the composition of the mill juice and the quality of the sugar produced by a number of mills in Negros.

Test No.	Mill juice.				Sugar made.		Reducing sugar per 100 sucrose.	
	Brix.	Sucrose.	Quotient of purity.	Reducing sugar.	Polarization.	Reducing sugar.	In juice.	In sugar.
1	18.70	14.84	79.16	2.46			16.6	
2	17.83	15.11	84.78	1.41	83.9	7.7	9.5	9.2
3	17.86	14.14	79.47		82.8	8.4		10.1
4	19.00	16.32	85.90	0.98			6.0	
5	16.65	14.29	85.82	1.21	76.2	12.8	8.5	16.8
6	17.12	14.20	82.96	1.56	77.1	11.8	11.0	15.3
7	19.74	17.23	87.26					
8	20.93	19.32	92.30	0.56	84.7 90.3	8.0 3.7	2.9	9.4 4.1
9	21.34	19.54	91.60					
10	20.70	19.63	94.82	0.26	88.2	5.1	1.3	5.8
11	20.30	17.94	88.37	1.12	81.6	7.9	6.2	9.3
12	20.35	18.03	88.61	0.98	87.9	8.2	5.4	5.9
13	20.45	18.71	91.47					
14	20.80	17.77	87.04	0.89	86.6	6.3	8.0	7.3
15	20.86	16.18	77.57	2.76	68.6	17.4	17.0	25.4
16	18.47	15.81	85.73	1.36	79.8	10.6	8.6	13.3
17	19.79	18.12	91.58	0.51	84.0	7.3	2.8	8.7
18	20.98	18.87	89.93	0.75	84.6	8.1	4.0	9.6
19	22.93	20.99	91.56	0.51	81.5		2.4	
20	19.10	15.72	82.31	1.61	76.7	12.1	10.2	15.8
21	20.98	18.35	87.48	1.30	80.7	8.6	7.1	10.6
22	19.74	16.37	82.92	2.06	68.4	15.8	12.6	23.1
23	18.77	15.70	83.68	1.50	78.3	9.5	9.6	12.1
24	17.57	14.93	85.00	1.17	85.0	8.4	7.8	9.9
25	21.06	19.18	91.07	0.69	84.5	7.6	3.6	9.0
26	19.40	17.10	88.20		86.4			
27	18.63	16.92	90.84	0.86	86.7	5.9	5.1	6.8
28	20.95	19.73	94.21	0.38	90.6	3.4	1.9	3.8
29	23.13	21.11	91.26	0.60	85.1	5.2	2.8	6.1
30	17.76	13.85	77.94	2.37	68.6	17.6	17.1	25.6
Average	19.71	17.20	87.03	1.20	82.0	8.9	7.4	11.4

Since no one sample of sugar could fairly represent the entire output of the hacienda from which it was secured, the sources of the different samples are not given, although it may be stated that they were taken from mills in the district of Bago, Pontevedra-La Carlota, Ilog-Cabancalan and San Carlos, and covered a period of time of about six months, or practically the entire grinding season of 1908-9, so that the average composition of the juices and sugars given should not be far from that of the whole island during that time. As a matter of fact, although possibly through coincidence, the average polarization of the sugar herein shown,

82°, agrees fairly closely with that just deduced from the records of sugar bought in Iloilo, 82°.6.

Examination of this table shows that there is much room for improvement in the manufacture of sugar as now carried on, even with the open-kettle process. Reduced to its simplest terms, this process consists merely in removing the water from a solution containing a certain percentage of sucrose, reducing sugars, salts, and organic matter not sugar, which, if evaporated to complete dryness under ideal conditions, would yield a product having the same polarization as the "quotient of purity" of the original juice. Clarification with lime, coupled with the increase shown by "true" over "apparent" purity, would still further raise the final polarization, so that it is theoretically possible to produce a concrete having a polarization a few degrees higher than the original purity of the juice. In the best practice this would be reduced from 2° to 5° by the hydration water necessarily retained by the reducing sugars and salts present, so that perfect sugar boiling, where no molasses is removed, might be considered to be the production of a concrete having the same polarization as the original "apparent" purity of the juice.

This limit is in rare cases rather closely approached, the two mill tests previously quoted, which represent very fair work, falling below it by 3° or 4°, while in the average of all the samples examined the polarization of the sugar made is 5° less than the original purity of the juice. Number 8 indicates the extent to which the quality of sugar produced may be influenced by care in manufacture; in this case a juice of 92.3 purity was yielding sugar which polarized only 84.7, the native sugar boiler in charge laying the blame on the canes ground, which, he said, were of inferior quality. The manager of the estate, acting on a suggestion to try a change of sugar boilers, brought over an experienced "maestro" from another estate, with the result that, from juice of identically the same quality, sugar polarizing 90.3 was produced. This gave a net gain of 50 centavos per picul in the price realized, or about 50 pesos per day. In each case the juice had been limed until it was practically neutral, the only difference in manipulation being the greater care and skill exercised by the more experienced "maestro" in supervising the final operation of boiling, and in allowing only thoroughly clarified juice to enter the No. 1 "caua."

It is an astonishing fact that so little attention is paid in Negros to the importance of skill and care in the manufacture of sugar, even by the present crude methods. Many planters, industrious and painstaking to an extreme degree as far as planting and field operations are concerned, appear to consider that once they have succeeded in raising a large crop of good and healthy cane their responsibility has ceased, and the details of manufacturing are turned over to a native contractor at so much a picul, or, if the mill is run by laborers furnished by the hacienda, a foreman may be nominally placed in charge, but the quality of sugar produced depends solely upon the

skill and the faithfulness of a native "maestro," who rarely receives more than 1 peso per day for his expert services. It may appear a broad statement, but it is one capable of demonstration, that not one planter in twenty is capable, in case of necessity, of himself going into the mill house, liming the juice properly, supervising the clarification, and determining the right concentration at which to remove a "cocida" of "massecuite" in order to secure the best quality of sugar therefrom.

COST OF MANUFACTURE.

If sugar is made by contract, the work is generally divided into the three operations—grinding the cane, boiling the juice, and drying the bagasse; the contract prices (in pesos per picul of 63.25 kilos) varying according to local conditions as follows:

Operation.	Highest.	Lowest.	Average.
Grinding the cane ..	0.17	0.08	0.15
Boiling the juice ..	16	.08	.15
Drying the bagasse ..	16	.08	.12
Total ..			42

To which must be added:

	Pesos.
Oil for lubrication.....	0.02
Bags (2 per picul).....	.12
Rattan for tying up bags.....	.02
Extra wages to sugar boiler and engineer.....	.03
Extra for labor of packing in bags and carrying to storehouse..	.04
Lime and coconuts or coconut oil	.02
Extra wood for boiler when bagasse is insufficient.....	.05
Total	.30

This makes a total cost of manufacturing sugar by contract of 72 centavos per picul, or 11.37 pesos per metric ton.

Of course, the above includes a certain profit to the contractors. When sugar is made exclusively by day laborers paid by the hacienda, the cost is generally somewhat less. For example, the typical hacienda previously assumed for the purpose of calculating the cost of cultivation, producing annually 6,000 piculs or 379.5 metric tons, would, allowing for stops and delays because of bad weather, etc., need a mill of about 8 nominal horsepower, with batteries of corresponding capacity, capable of turning out an average of 80 piculs, or about 5 metric tons, of sugar per day in order to grind the whole crop in three months or seventy-five actual working days. The daily expenses of operating such a mill would be approximately as follows.

Estimate of the approximate daily cost of operating a sugar mill in the Island of Negros, producing an average of 80 piculs or 5 metric tons of sugar per day of fourteen hours, no charge being made for supervision, depreciation of the plant, or interest on the capital involved.

Item.	Cost in Philip- pine cur- rency.	Item.	Cost in Philip- pine cur- rency
	<i>Pesos.</i>		<i>Pesos</i>
1 "maestro," or sugar boiler.....	1.00	8 "suplillos," for transferring juices	
1 engineer	1.00	and sirups from one "caña" to	
1 fireman for the engine boiler.....	.40	the other, at 40 centavos each.....	3.20
2 water carriers for the engine boiler,		8 "azucadores," for crystallizing the	
at 40 centavos each	.80	"massecuite" and packing the sug-	
4 firemen for the batteries, at 40 cen-		ar in sacks and carrying it to the	
tavos each	1.60	storehouse, at 40 centavos each.....	3.20
10 "cambiadores," for unloading		To cost of labor, 10 per cent addition-	
cane and carrying it to the mill,		al for stoppages and delays.....	2.72
at 40 centavos each	4.00	Lime for clarification of juices (1.5	
2 "planchadores," for feeding the		cavanes, at 0.50 centavos per cavan).....	.75
mill, at 40 centavos each.....	.80	Coconuts or coconut oil for use in	
6 "manogsalu," for carrying bagasse		"caña" No. 1.....	.50
from the mill to the plaza, at 40		Lubricating oil for engine and mill ..	.75
centavos each	2.40	Grease for mill	.50
20 laborers for sun drying the bagasse		Firewood for boiler when bagasse sup-	
in the plaza and storing it under		ply is insufficient.....	4.00
shelter when dry, at 40 centavos		Kerosene oil for lighting the mill	
each	8.00	house at night	1.00
1 laborer stationed at the mill to keep		160 bags, 2 per picul, at 7.00 pesos per	
mill bed free from bagasse and		100	11.20
make himself otherwise useful	.40	1,000 pieces bejuco (rattan for tying	
1 laborer to look after the juice		up bags)	2.00
canal, etc.....	.40	Total.....	50.62

The bare cost in the mill house, then, for manufacturing 80 piculs or 5.06 metric tons of sugar may be placed conservatively at 50.62 pesos, which is at the rate of 63 centavos per picul, or 10 pesos per metric ton.

TRANSPORTATION AND SALE OF THE SUGAR.

Growing the cane and manufacturing it into sugar does not end the labors of the planter in Negros; he must bring the sugar to the seacoast or the closest lorchá anchorage, load it, and arrange for its reception and sale at Iloilo. If he is fortunate enough to own a plantation near the sea or on the banks of some navigable river, loading the boat will only cost him 1 or 2 centavos per picul (16 to 32 centavos per metric ton), while his neighbors farther inland must bring their sugar down a few tons at a time in carabao carts over not the best roads in the world, paying in extreme cases as high as 30 centavos per picul (4.75 pesos per metric ton). The average planter pays probably 10 centavos per picul, or 1.58 pesos a metric ton. Transportation

to Iloilo, as has already been stated, is effected in lorchas—small, flat-bottomed schooners especially built for this trade, of very light draft, and having a capacity of 100 tons or less—the freight rate varying, according to distance, between 15 and 30 centavos per picul (2.37 to 4.74 pesos per metric ton) and averaging 20 centavos per picul (3.16 pesos per metric ton). Once in Iloilo, the sugar is taken in charge by the planter's agents, who attend to the discharging, weighing, classifying, repacking, etc., and either sell it at the market rate, or store it subject to orders in their warehouses.

Cost of shipping the sugar to Iloilo and selling it there.—The expenses ordinarily incurred in disposing of the sugar after it leaves the hacienda, reduced as nearly as possible to average distances and costs, are summarized in the accompanying table:

Estimate of the approximate cost of transporting sugar from a plantation on the Island of Negros to the city of Iloilo and there selling it, charges being quoted in Philippine currency per picul and per metric ton.

Item.	Per picul.	Per met- ric ton.
	Pesos.	Pesos.
Transportation to the lorchas landing and loading aboard the lorchas	0.10	1.58
Freight from Negros to Iloilo	.20	3.16
Discharging in Iloilo	.015	.24
Replacing 15 per cent of damaged bags (material)	.02	.32
Labor of repacking	.04	.64
Weighing	.008	.13
Receiving in agent's warehouse	.01	.16
Agent's commission (2 per cent of selling price)	.14	2.22
Total	.533	8.45

QUANTITATIVE EXPERIMENTS TO DETERMINE THE WEIGHT OF SUGAR PRODUCED FROM A GIVEN WEIGHT OF CANE

Although by comparative analyses of cane and bagasse it is possible to determine with considerable accuracy the percentage extraction of juice by a mill, without weighing either the cane ground or the juice and bagasse produced, and while a knowledge of the composition of the juice affords a means of approximating the yield of sugar which might be produced therefrom, it has heretofore not been practicable in Negros, owing to the lack of any large scales for weighing cane, actually to determine the yield in practice. After several unavailing attempts in other places to determine this yield, I was finally enabled through the courtesy of the owners and the manager of the hacienda San Jose, San Carlos, to make two complete chemical controls of the mill at this

place, covering periods of about twelve hours' run each, on two fields of cane of very different composition. The figures resulting from these tests, while necessarily not of a high degree of accuracy, are yet as reliable as it was possible to make them with the limited facilities at hand. As only one pair of scales (with a maximum capacity of 500 Spanish pounds) was available for weighing cane and bagasse, it was found necessary to weigh the cane during the course of one day, store it under shelter over night and grind the next day, thus leaving the scales available for weighing bagasse.

The weight of cane actually ground was calculated by subtracting the loss in water by evaporation as determined from a small sample of 1,000 pounds stored under the same conditions. The bagasse was weighed as it came from the mill, in lots of 200 pounds, a sample of 200 grams being taken from each lot and placed in a box over the boiler to dry for analysis. At the end of the run this was chopped into fine pieces, reweighed, quartered, and analyzed, and results calculated back to the fresh bagasse and the original cane. The weight of juice was estimated by difference between that of cane and bagasse.

Although the customary methods of boiling in this locality were followed with as little deviation as possible, some allowance must be made for the mental strain on the native workmen, who were somewhat at a loss to understand the meaning of such an innovation in their ordinary routine; also for the fact that to avoid fracturing the "cauas" it was necessary to follow up the last boiling of juice with pure water, thus incurring a slight loss of a liter or so of juice left behind in each kettle, which in the usual practice would not have occurred. Furthermore, it may be stated that these tests, although fairly representative of the working of the average sugar house in Negros, are no longer so of the hacienda on which they were made, as an entirely new plant has been installed there within the past six months.

MILL CONTROL NO. 1, HACIENDA SAN JOSE, SAN CARLOS (MAY 1, 1909).

Equipment.—The mill used was of 12 nominal horsepower, rollers 56 by 106 centimeters, power supplied by a multitubular boiler set between the batteries and the chimney, but provided with an independent firing door; steam pressure about 60 pounds to the square inch (4.2 atmospheres). The mill juice runs through an open trough to a series of batteries arranged according to the usual manner, two parallel sets of four in series with the "No. 5" in common. During the experiments one side only was used. No filter presses of any kind were employed, the skimmings from the cauas being thrown into an iron scum tank, which, when full, was allowed to settle as much as possible, the clear juice run back into the battery, and the residue discarded.

Process of manufacture.—With the exception of the liming of the juice, which, for the sake of uniformity, was all made barely alkaline to litmus in the No. 5 "caua," the details of manufacture were left entirely to the native sugar boilers, with instructions to go ahead precisely as was their usual custom.

Kind of cane used. The cane ground in this test was from the same field as that taken for "cane analysis No. 42," district of San Carlos, previously quoted as containing fiber 12.51 per cent, sucrose 18.01 per cent, with an exceedingly pure juice of the composition: Brix, 23.0; sucrose, 21.21; quotient of purity, 92.15; reducing sugar, 0.22. The field was not very thickly grown, and the cane itself had been much stunted by exceptionally dry weather, so that the cane stalks averaged only 410 grams in weight. It was estimated by the manager of the plantation that this field would produce about 40 piculs of sugar per hectare (2.5 metric tons). A section comprising 8,663 square meters was measured off, and the cane on it ground, with the following yield:

Cane actually ground, 18,479 kilos, or 21.3 metric tons per hectare.

Bagasse produced, 8,091 kilos.

Analysis of bagasse: Dry substance, 46.38 per cent; sucrose, 11.84 per cent (corresponding to "mill juice" 56.07 per cent); fiber, 33.42 per cent; "mill juice," per 100 fiber, 168.

Juice extracted, 10,388 kilos, of composition: Brix, 23.13; sucrose, 21.11 per cent; "quotient," 91.26; reducing sugar, 0.60 per cent.

Sugar made, 2,060 kilos, of composition: Sucrose, 85.11 per cent; reducing sugar, 5.24 per cent.

Skimmings thrown away, 699 kilos, of composition: Sucrose, 28.72 per cent; reducing sugar, 0.89 per cent.

Without entering into details of the calculation, the percentage yields and losses during the experiment, derived from the above data, may be summarized as follows:

Summary of mill control No. 1.

	Per cent.
Sucrose in cane ³¹	17.05
Fiber in cane	14.63
Juice extracted, on weight of cane	56.22
Sucrose extracted:	
In juice, on weight of cane	11.87
In juice, on sucrose in cane	69.60
Raw sugar produced, on weight of cane	11.05
Average polarization of sugar produced	85.11 ³²
Sucrose produced:	
On weight of cane	9.49
On sucrose in cane	55.67
On sucrose extracted in juice	79.98

³¹ "Sucrose" in these tests refers to the percentage indicated by direct polarization. True sucrose by Clerget would, of course, be a trifle more.

³² In ordinary working, the polarization of the raw sugar produced would have been a few degrees higher. In an endeavor to work up as much of the skimmings as possible in the final boiling, some impurities were introduced in the clarified sirup, which resulted in an inferior grade of sugar from this *cocida*. The previous boilings had averaged about 87 polarization. In practice, skimmings are filled into alternate tanks and allowed to stand until they settle, which was impossible in a test of only 1 day's duration.

Sucrose lost—	On weight of cane.	On sucrose in cane.	On sucrose extracted in juice.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
In bagasse	5.18	30.40	-----
In skimmings.....	1.09	6.38	9.17
By inversion (from excess of reducing sugar in final product over that originally present in juice)	0.27	1.56	2.23
Apparent, or analytical (one-third of excess of reducing sugar)	0.09	0.54	0.78
Burned in manufacture, spilled, and unaccounted for	0.93	5.45	7.84
Total loss	7.56	44.33	20.02

The percentage of sucrose lost in the bagasse in this test is considerably higher than is the general rule in Negros, which, as estimated previously, amounts on an average to a little less than 25 per cent of the total sucrose in the cane.

This is not the fault of the mill, which, when tested previously when grinding a similar cane, produced a bagasse containing 169 parts "mill juice" to 100 fiber, while the figure derived from the present new mill is 168, a very close agreement, and somewhat better than the average mill in Negros. The loss rather is due to the larger amount of fiber which these very dry canes carry, this being aggravated by the introduction of about 2 per cent more fiber in the shape of dry leaves, etc. Comparing "Cane analysis No. 42," as made on a sample of 20 canes taken from this field and ground in a hand mill, with the composition of the same field deduced from the present mill control, very little difference will be noted as far as the quality of the expressed juice is concerned; Brix and sucrose agree within 0.1 per cent, although, as the differences are in opposite directions, the indicated purity of the mill juice from the large mill is almost 1 per cent lower than that previously found by analysis; reducing sugar in the mill control is 0.60 per cent against only 0.22 found previously, but the difference is partially accounted for by the fact that the cane ground on a large scale had stood over night before grinding, while the small sample had been analyzed immediately after cutting. Cutting the cane tops a little higher up than was done for analysis might also increase the percentage of reducing sugar.

The extent to which the introduction of cane trash into the mill will reduce the yield of sugar is clearly brought out by comparing these two analyses: The clean cane previously was found to contain only 12.51 per cent of fiber, while the figure derived from the analysis of bagasse during the mill test was, when calculated back to the weight of the cane ground, 14.63, a difference of 2.12 per cent, which could only be due to trash. Since it was found that in the mill 168 parts of juice are held back by each 100 parts of fiber, it is evident that if only clean canes had been ground the extraction of juice would have been 3.56 per cent greater, so that 59.78 per cent of juice on the weight of the cane might have been obtained instead of the 56.22 per cent which it actually yielded. In other words, an increased extraction of juice and consequently of sugar over that really produced, of $\frac{3.56}{56.22}$, or 6.95 per cent, would have resulted, or in case of the average

small factory making sugar to the value of, say, 500 pesos per day about 35 pesos more per day would be gained by having the cane perfectly clean before it enters the mill. Six laborers in the mill at an extra cost of 2.40 pesos per day should be able to free all the cane from trash as it comes from the field and would repay the additional expense for their services many times over. The above remarks should not be construed as reflecting against any one hacienda or district in particular, but apply equally as well in nearly every other part of Negros.

The percentage of sucrose lost in the skimmings, working with such a rich juice and no filter press, was considerably higher than that which might ordinarily be expected, as the scums, because of their high density (sucrose, 28.72 per cent), were very slow to settle, and a tank full yielded only about two-thirds of its volume of clear juice, the remaining third being thrown away. The loss due to caramelization was somewhat less than the average, since less time was required for evaporation, and the fairly pure "massecuite" could be carried down to the desired low-water content with comparatively little danger from burning, so that a very light-colored sugar was produced. The figures denoting loss by inversion have in reality very little value as showing the real amount of inversion taking place, but simply give the amount of invert sugar produced and which happened to escape destruction by overheating, remaining as such in the final product.

Finally, taking into account the large losses of sucrose incurred in milling, and in fact throughout the entire process of sugar making, it should be noted that the actual weight of raw sugar produced, referred to the weight of cane crushed, is by no means as small as might ordinarily be believed. This is so because of the retention of all soluble impurities and molasses in the concrete; so that from the juice extracted as much if not more *low-grade* sugar is yielded by the present process than could be secured from the same amount of juice in the form of 96° crystals by a modern factory, although, of course, the recovery expressed in terms of sucrose is very much less.

Thus, in the present instance 1 ton of cane produced 0.1115 ton of sugar, or to produce 1 ton of sugar required 8.97 tons of cane, a ratio which would be considered very fair work in many countries where even the best and most economical working might not, on account of the poorer quality of cane dealt with, turn out more than 0.1 ton of sugar (96°) per ton of cane. Calculated to the hectare of land, the field used for this test produced 21.33 metric tons of cane and 2.378 metric tons, or about 38 piculs, of sugar per hectare, a very poor yield for the locality, but just about what had been expected, since it was one of the poorest fields in the hacienda.

MILL CONTROL NO. 2, HACIENDA SAN JOSE, SAN CARLOS (JUNE 1, 1909).

Kind of cane used.—The field from which this cane was taken has been discussed under "Cane analysis No. 46," District of San Carlos, where it was cited as an example of the effect of drought on very young cane in changing it from a state of immaturity to one of decay without giving it an opportunity to become fully ripe. The field itself is in general considered one of the best in the locality,

both as to quality and quantity of cane produced, and the same was indicated by analysis, where care was taken to exclude both decidedly immature and dead or decaying canes. The composition of normally developed cane from this field was then found to be: Average weight, 1.06 kilos; fiber, 9.89 per cent; sucrose, 16.76 per cent; juice—Brix, 21.33 per cent; sucrose, 19.26 per cent; purity, 90.31; reducing sugar, 0.85. In practice it was found to be impossible to throw out all the young or the overripe cane before grinding, so that the material actually ground bears no relation to the normal specimens analyzed, but serves as an example of what may be expected from the average mill in Negros when working on an inferior quality of cane and juice. This test was made during the last few days of the grinding season, and the small portion of the field yet remaining to be ground was so irregular in shape that no attempt was made to measure it accurately. Estimated by the eye alone the yield must have been about double that of the field for the previous test, since the individual canes, although of much poorer quality, were more than twice as large, and much more thickly grown. The process of manufacture was carried on precisely as in Control No. 1.

Weight of cane actually ground, 24,520 kilos.

Bagasse produced, 8,810 kilos, of composition: Dry substance, 39.78 per cent; sucrose, 8.18 per cent (corresponding to "mill juice" 59.06 per cent); fiber, 29.29 per cent; "mill juice" per 100 fiber, 202.

Juice extracted, 15,710 kilos, of composition: Brix, 17.76; sucrose, 13.85 per cent; "quotient," 77.94; reducing sugar, 2.37.

Sugar made, 2,311 kilos, of composition: Sucrose, 68.60 per cent; reducing sugar, 17.58 per cent.

Skimmings thrown away, 804 kilos, of composition: Sucrose, 13.7 per cent; reducing sugar, 2.58 per cent.

The percentage yields and losses during this test were:

Summary of mill control No. 2.

	Per cent.		
Sucrose in cane.....			11.81
Fiber in cane.....			10.52
Juice extracted, on weight of cane.....			64.07
Sucrose extracted in juice, on weight of cane.....			8.87
Sucrose extracted in juice, on sucrose in cane.....			75.13
Raw sugar produced, on weight of cane.....			9.42
Average polarization of sugar produced.....			68.60
Sucrose produced on weight of cane.....			6.47
Sucrose produced on sucrose in cane.....			54.73
Sucrose produced on sucrose extracted in juice.....			72.85

Sucrose lost—	On weight of cane.	On sucrose in cane.	On sucrose extracted in juice.
	Per cent.	Per cent.	Per cent.
In bagasse	2.94	24.87	
In skimmings.....	0.45	3.81	5.06
By inversion (from excess of reducing sugar in final product over that originally present in juice)	0.21	1.80	2.39
Apparent or analytical (one-third of excess of reducing sugar).....	0.07	0.62	0.83
Burned in manufacture, spilled, and unaccounted for.....	1.67	14.17	18.87
Total loss.....	5.34	45.27	27.15

The per cent of total sugar lost in bagasse here, 24.87, approaches more nearly the average for Negros, as would be expected from the fiber content of the cane ground. That this latter does not show such a marked increase due to added trash over that previously found by analysis is probably accounted for by the larger proportion of young and tender canes ground in the test, tending to reduce the fiber actually present in the clean cane.

Comparison of the work done by the mills in these two controls emphasizes the fact that we have as yet no reliable standard for absolute mill efficiency which applies when different kinds of cane are being ground. There is no reason to believe that any marked variation in the working of this mill took place between the first and the second test, yet, measured by "extraction," much superior work was accomplished in the latter, 75.13 per cent of the total sucrose in the cane being secured as against 69.60 per cent in the former, while, on the other hand, if we apply Watts's factor of "first mill juice per 100 parts fiber of bagasse" we must believe that the better work was done in the first test, since there only 168 parts mill juice were left in the bagasse per 100 fiber, compared with 202 parts found in the last control. These differences are far too great to be attributed to errors of analysis, and the sampling was conducted in such a manner and over so long a time (the final mixed sample of bagasse from Control No. 2, for instance, was made up of 95 separate 200-gram samples taken at regular intervals throughout the day) as to neutralize by mere numbers much of the unavoidable error inherent to this part of the work. There remains, therefore, only the qualitative difference in the fiber from these two kinds of cane. As a matter of fact, the variety of cane ground was the same in both cases, both being of the common purple kind, although that used in the first test was old, hard, and dry, while the second was comparatively young and tender. Just as in the previously stated results with the hand mill (see p. 95), the fiber from the soft and juicy canes was found to retain a proportionately larger amount of juice than that from the harder ones, although, since the total amount of fiber present was less, the "extraction" was better.

It is possible that this effect of the qualitative difference of cane fiber is peculiar to single crushing, and might tend to disappear in the case of mills run in multiple and with pressure regulators, as is indicated by the recent work of Deerr,²⁸ who found on analyzing separately the bagasse of the hard rind and the soft pith of the cane, as it came out from the different mills of a multiple-roller train, that rind bagasse from the first mill contained more fiber and less sucrose than pith bagasse; in the second mill the amount of sucrose left in pith

²⁸ Exp. Station Hawaiian Planters' Ass. Bull. No. 30 (1909).

and rind was about the same, although the rind still contained less sucrose per unit weight of fiber; while the third, fourth, and fifth mills yielded a much more completely exhausted pith bagasse without materially reducing the sucrose content of the rind. He concludes from this "that the milling process is very effective so far as regards the soft interior pith, but very crude as regards the extraction of sugar from the hard outer rind." This might indicate that canes possessing a soft fiber should allow of more efficient mill work than harder ones, provided more than six rollers are used. The opposite has been found true, however, by Geerligs³⁴ in Java, who says that "in most cases, canes having a high fiber content will yield bagasse the fiber of which offers but little resistance to pressure. This to some extent compensates for the increased loss of sugar occasioned by the large amount of bagasse obtained from canes of high fiber content. From the average of a great number of determinations it is seen that a high fiber content of the cane corresponds with a high fiber content of the bagasse, so that a hard cane yields a drier and more exhausted bagasse than a soft one." It is evident that there still is room for much work before this question can be solved.

Returning to Negros and the mill controls, it is seen that working with a poor juice, much less sucrose is lost in the skimmings than with a richer one, this because a lower density allows of more rapid and complete settling of impurities in the scum tanks, while volume for volume the skimmings from an inferior juice of course contain less sucrose. The loss by inversion, as far as could be detected by analysis, is about the same in each case; that caused by burning is enormously larger in the second experiment than in the first, and it is my belief that, in making "corriente" sugar from poor juice, much sugar is not only inverted and caramelized, but literally burned, some of it even forming gaseous products. The fumes from a very low-grade "massecuite" during the last portion of the boiling are sometimes so irritating as to be unbearable even to the native workmen.

The total losses in manufacture, referred to the sucrose in the cane, were not far different in each experiment, the poor cane losing only about 1 per cent more of its sucrose than the better one. As regards yield of raw sugar, this was somewhat less in the second test, but not so much as might be expected from the poorer quality of cane ground, since the loss in sucrose is largely compensated for by the larger amount of impurities turned out as "sugar." The yield of "corriente" sugar from this inferior cane was 0.942 tons per ton of cane, so that 10.61 tons of cane would be required to produce 1 ton of sugar.

Calculation of the average yield of raw sugar per ton of cane in Negros.—Combining the data brought out by all these experiments, the average losses of sucrose during the process of sugar making as carried on

³⁴ Cane Sugar and its Manufacture. Manchester (1909), 105.

in Negros are, expressed in percentages of total sucrose present in the cane, approximately as follows:

Loss —	On total sucrose in cane, Per cent.
In bagasse	25.0
In skimmings (where no filter press is used).....	5.0
By inversion (including "apparent" or analytical losses)	2.5
Burned, spilled, stolen, and unaccounted for.	10.0
"Shrinkage" ^a en route to Iloilo (including "tare")	1.5
Total	44.0

^a This loss amounts to about 2.5 per cent of the total sugar produced. Since the sugar is, as a rule, not weighed accurately until it reaches Iloilo, and all estimations of the yield of an hacienda are based upon Iloilo weights, it is proper to include this loss in shipping with the other losses incident to manufacture and calculate it to per cent sucrose in cane.

Clean, ripe cane has already been shown by analysis to average as follows in four of the most important districts of Negros: Fiber, 10.02 per cent; sucrose, 16.06 per cent; with a juice, as expressed by moderately strong single crushing, of Brix, 20.35; sucrose, 18.40; purity, 90.38. In practice, the addition of about 2 per cent of cane trash has likewise been shown to increase the per cent of fiber in the cane as ground to 11.79 per cent, and reduce the sucrose to 15.75 per cent, so that the physical make-up of the cane would be fiber, 11.79 per cent; "juice" (of above composition), 85.57 per cent; "water other than juice," 2.64 per cent.

The juice from a large number of mills in Negros was found to average somewhat lower in sucrose and purity than that determined by analyses of small samples of cane, and it is very probable that, owing to carelessness in cutting and the introduction of more or less immature and dead cane into the mill, the juice of the cane actually ground would be represented more truly by the former figures than by the latter, so that the average cane of Negros as ground in the mill may be assumed to have approximately the following composition: Fiber, 11.79; juice (of the composition—Brix, 19.71; sucrose, 17.20 per cent; purity, 87.03 per cent; reducing sugar, 1.2 per cent), 85.57 per cent, corresponding to a total of sucrose in cane of 14.72 per cent.³⁵

From the estimate of losses in manufacture just made it is seen that on an average 44 per cent of the total sucrose is lost in manufacture and 56 per cent recovered as raw sugar, so that the yield in sucrose per weight of cane would amount to 8.2 per cent, or, since the average

³⁵ Throughout this paper percentages have been generally expressed to two places of decimals, without, however, making any pretense at such extreme accuracy. Analytical work of this nature can usually be relied upon to about $\pm$ 0.2 per cent.

raw sugar made throughout the island contains 82 per cent sucrose, 1 ton of cane will yield almost exactly 0.1 ton of raw sugar.

This ratio of 10 to 1 will hold good with comparatively little variation throughout Negros, since, in the process of manufacture which is employed, the kind of cane ground affects the quality rather than the quantity of sugar produced. The extreme limits of variation may be set at approximately 11.5 per cent and 9 per cent, respectively, on the weight of the cane.

CALCULATION OF THE AVERAGE COST OF PRODUCING SUGAR IN NEGROS
BY THE METHODS NOW EMPLOYED.

With the description of each step in the production of sugar in Negros, from the first cultivation of the soil to the marketing of the finished product in Iloilo, there has been included as careful an estimate as it was possible to secure of the average cost for labor in each operation, reducing the same to the unit bases of the picul³⁶ and the metric ton³⁷ of sugar produced; the picul because it is still the best known unit of weight among those locally interested in sugar production, and the metric ton as having the most widespread significance throughout the world in general. All prices are figured in Philippine currency.³⁸

Summary of the cost of producing sugar in Negros, as calculated in the previous portion of this paper.

Item.	Cost per picul of sugar.	Cost per metric ton of sugar.
	<i>Pesos.</i>	<i>Pesos.</i>
Plowing, planting, and caring for the cane until it is ready to cut (from p. 88)	0.60	9.49
Cutting the cane (from p. 92) -----	.16	2.53
Carting the cane to the mill (from p. 92) -----	.16	2.53
Grinding the cane and manufacture of sugar (from p. 112)	.63	9.96
Cost at the hacienda (from p. 113) -----	1.55	24.51
Shipping to Iloilo and marketing there (from p. 114) -----	.53	8.38
Total -----	2.08	32.89

The above represents the bare cost of production and placing upon the market, and it is not surprising that those who stop at this point in their calculations should marvel at the fact that all Negros planters are not millionaires, when they can lay down sugar in Iloilo for about 2 pesos a picul.

A sugar plantation, however, like any other farm, represents a

³⁶ 1 picul equals 63.25 kilos, or 139.44 avoirdupois pounds.

³⁷ 1 metric ton equals 2,204.6 avoirdupois pounds, or 0.9842 "long" ton.

³⁸ 1 peso Philippine currency equals 50 cents United States currency.

considerable capital invested in land, animals, and equipment, and in addition to this requires no small outlay for special machinery, which, crude though it may be, becomes decidedly expensive by the time it has been brought to Iloilo, reshipped to Negros, and set up there on the hacienda. A sufficient working capital is also needed to pay advances to laborers, salaries and living expenses of the administrator and his assistants, and to keep the farm going until the sugar is sold. On all of this capital legitimate charges for interest and depreciation must be made and the total calculated to the amount of sugar made during the season before the true cost of production can be determined. This is a most difficult matter even roughly to approximate, and absolutely impossible at present to state with certainty, because of the enormous variations in the size, resources, and management of different haciendas. Unfortunately, those who are really well informed on this subject, as is the case in almost any other business, are as a rule the least anxious to give the general public the benefit of their knowledge. A fairly good idea of the fixed expenses on an ordinary sugar plantation may be obtained by assuming a typical hacienda of about average size and figuring out in detail the capital tied up in land, buildings, farm implements, machinery, work animals, etc., and adding to the depreciation and interest on this sum a certain amount for administration and household expenses. Such an ideal hacienda has already been assumed in connection with the calculation of the expenses for labor in the field. In that case it was found necessary to assume a plantation a little better cared for than the average, in order to obtain any reliable data, since the very poorest places, which reduce the general average of yield, have as a rule, no fixed system of cultivation which they follow, but expend a greater or less amount each year according as they may possess the capital or the credit to work with. For the same reason it is even more necessary in calculating fixed expenses to consider a place somewhere nearly adequately equipped for the work in hand, therefore the equipment and general expenses set forth in the following estimate will, per hectare of land, run somewhat higher than those of the average plantation in Negros at the present time. At the same time the estimated yield of 60 piculs (3.8 metric tons) of sugar per hectare of land is proportionally higher than the average of 42.9 piculs (2.7 metric tons) now secured, so that the amount of money expended will, when reduced to the unit of sugar made, not differ greatly in each case. This departure from strictly average conditions is an admitted defect in the calculation, but is justified by the much greater accuracy of information obtainable.

The hacienda about to be considered by no means represents the best equipment, or most efficient management, at present existing in Negros, but may be taken as a type of the average place not unduly

hampered by the lack of capital or credit. It may be added that this is a purely imaginary plantation and is not intended to describe any one place now in operation on the island.

Estimate of the cost for land, equipment, and maintenance of a sugar plantation in Negros containing 150 hectares of land, 50 of which are cultivated in new plant cane, 50 in ratoons, and the remainder left uncultivated, the annual production being assumed to be 6,000 piculs or 379.5 metric tons of raw sugar of an average polarization of 82°

Item.	Cost in Philippine currency.
LAND.	
150 hectares, at 100 pesos per hectare	15,000
EQUIPMENT.	
Boiler, engine, and sugar mill of 8 nominal horsepower, having a capacity of 80 piculs or 5 metric tons of sugar per day, landed and set up ready for operation in Negros	10,000
9 iron "cauas" or sugar kettles set up on the hacienda	900
Materials and labor used in constructing the bagasse furnace, the brick or stone work for the battery of "cauas," and the chimney	3,000
Materials and labor used in constructing the "camarin" or sugar house	2,000
Materials and labor used in constructing two bagasse sheds	1,500
Materials and labor used in constructing one dwelling house for manager and foreman	2,000
Materials and labor used in constructing 40 light-material houses for plantation laborers, at 40 pesos each	1,600
50 work animals (cf. p. 88), at 135 pesos each	6,750
20 carts for hauling cane and sugar, at 50 pesos each	1,000
1 ^a kilometer portable tramway with 50 meters of curve sections and ten 1-ton cane cars, laid down on the hacienda	3,500
40 plows, at 20 pesos each	800
Other agricultural implements, such as harrows, hoes, bolos, etc.	1,000
Advances to laborers ^b	3,000
Total	37,050
MAINTENANCE (AND RUNNING EXPENSES).	
Interest on the value of the land (15,000 pesos) at 10 per cent per annum	1,500
Interest (10 per cent) and depreciation (10 per cent) on the equipment (37,050 pesos)	7,410
Taxes (0.5 per cent of value of land and equipment)	260
Salary ^c of manager, at 100 pesos per month	1,200
Salary of 1 "dependiente" or European foreman, at 50 pesos per month	600
Wages of 2 "cabos" or native foremen, at 20 pesos per month each	480
Household expenses of manager and foreman, at 80 pesos per month	960
Total fixed expenses per annum	12,410

^a This is hardly sufficient tramway for a plantation of this size, but as many have no tramway at all it was thought best to include only 1 kilometer here and make up the deficit with cane carts.

^b Since a portion of this capital is invariably lost through laborers breaking their contracts and running away after securing advances, it is proper to include the amount advanced under "equipment" and subject it to depreciation as well as interest.

^c The manager of an estate is generally paid a nominal salary and his living expenses, receiving every year a bonus of a certain percentage of the net profits for the season.

The above fixed charges, when calculated to the amount of sugar produced, result in an additional cost of 2.07 pesos per picul, or 32.72 pesos per metric ton, and the total cost, including everything, of producing sugar in Negros and marketing the same in Iloilo may be stated with some degree of accuracy to average 4.15 pesos per picul, or 65.61 pesos per metric ton.

Many planters undoubtedly turn out sugar at a much less cost, especially those located in the more fertile districts where it is not necessary to replant oftener than every three or four years, but there are many others who must plant afresh each year and consequently spend considerably more than the above figure. It should be remembered that these costs are supposed to include everything, with interest on the capital permanently invested at the rate of 10 per cent per year, the rate charged by the Agricultural Bank. In the case of the few planters using their own capital, if no interest is charged on this, the cost of production would be reduced to 3.28 pesos per picul or 51.86 pesos per metric ton.

POSSIBILITIES FOR IMPROVEMENT.

IN CULTIVATION.

The desirability of introducing a few other well-selected varieties of cane as a temporary or permanent substitute for the purple, in case of disease, has already been discussed. With a well-equipped experiment station, some work may be done toward raising seedling canes and possibly evolving new varieties still better adapted to local conditions. As regards cultural operations, it has been stated by those claiming to know that the Negros planter as a rule does not go deep enough in his first plowing, and should pay more attention to the harrow instead of the plow for subsequent operations. With an ordinary moldboard plow, and a carabao as the motive power, not much improvement in depth can be expected, although better results are said to have been obtained in some cases by use of the disc plow. The substitution of mules for carabaos has been suggested, but is hardly considered feasible at present owing to the high cost and uncertain mortality of the latter animals. Steam plowing engines are without doubt the most efficient method of caring for large estates, but their first cost puts them out of the reach of the small planter. Irrigation during a few months of the dry season would probably double the yield of cane in certain districts; others rarely suffer from drought, but much from excess of rain, especially where the soils are heavy clay. The latter would undoubtedly be benefited by sub-soil drainage.

The question of the application of commercial fertilizers is, in my own opinion, one which can only definitely be settled by the practical results obtained by each planter on his own particular estate; fertiliza-

tion on a large scale might prove of great advantage on some soils, and yet result in pecuniary loss on others. All these problems, however, lie more within the province of the agriculturist than of the chemist. I am inclined to believe that the Negros planter has been rather undeservedly maligned in the past as regards his industry and capability. Considering the hardships he has had to contend with, the yield of cane he gets from his land is by no means as bad as might have been expected, and the increase in his available capital brought about by the present high price of sugar should alone greatly improve the condition of cane culture in the Island. However, as long as each individual planter is compelled to devote half his attention to the details of the manufacture of sugar, thereby neglecting his fields, the industry as a whole can never attain its maximum development.

IN MANUFACTURE.

This brings up the question of modernizing our methods of sugar making. It is a fact, undisputed by even the most ignorant on the subject, that three or more powerful mills in series will extract more juice from a given amount of cane than will the ordinary three-roller single mill, and that the sugar from this juice may be secured in a purer form and with less loss by the aid of vacuum pans and centrifugals than by open-pan boiling and crystallizing with a spade. Unfortunately, the necessary adjuncts to modern sugar fabrication are rather expensive articles, and not adapted to the use of small estates—even if they were, they would hardly yield happy results in the hands of the native sugar “maestro”—since to secure the most economical returns a modern mill should have a daily capacity of not much less than 500 tons of cane and should be kept driven at its full capacity without interruption during a grinding season of about one hundred days, which would necessitate a certain supply of 50,000 tons of cane. This amount would correspond to a total output per year under the present system of about 5,000 tons or 80,000 piculs of raw sugar, or about three times that of the largest estate on the island.

CENTRAL FACTORIES.

A sufficient quantity of cane to operate even a small-sized modern mill could only be supplied by combining the crops of a number of haciendas in the same immediate neighborhood so as to grind at one centrally located place, and since at the present day it is hardly possible to find in one district a group of planters possessed of sufficient capital and at the same time of sufficient confidence in one another harmoniously to operate a coöperative central factory, this would in all probability have to be erected and managed by outside capital. Now, the average sugar planter is a singularly practical individual, and probably would not be satisfied with the purely scientific pleasure of knowing that

his cane was, by improved methods, being turned into sugar of a much superior color and higher optical rotation, unless the benefit thereby resulting to him were made evident in terms of Philippine currency. The central factory, on the other hand, is not ordinarily conducted as a philanthropic enterprise, but represents a large amount of capital—often greater than the combined value of the farms from which it draws its supply of cane—on which dividends must be paid. To be satisfactory to all parties concerned, then, a change to modern methods of manufacture must not only yield the planter a greater profit than he is now receiving from his cane, but must likewise pay interest, depreciation, and dividends on an equal or larger investment represented by the central factory; in other words, from the same weight of cane just about double the amount of pesos must be extracted than are now being yielded by the process in use.

The methods of apportionment of the sugar produced vary in different countries, but as a rule the farmer receives from 45 to 55 per cent of the value of the sugar secured from his cane, according to local conditions and as to whether delivery is made at the central factory or on the hacienda. Taking 50 per cent as the average, without, however, assuming that this would necessarily be the most equitable ratio here, and leaving the prospective manufacturer as the most competent judge of what his share in the profits of such a transaction might be, it may be of interest to calculate approximately what would be the gain or loss to the planter if he should receive the value of half his cane only, manufactured into 96° centrifugal sugar, instead of the whole of it as 82° concrete as at present. It will be necessary to assume for such a calculation a fixed price for the two grades of sugar.

The price paid in the Iloilo market for Negros sugar has averaged during the first five months of this season, beginning November 1, 1909, about as follows:

Grade.	Price per picul.	Price per metric ton.
Superior:	<i>Pesos.*</i>	<i>Pesos.</i>
No. 1	7.50	118.59
No. 2	7.25	114.63
No. 3	7.00	110.68
Assorted	7.125	112.66
Wet	5.625	88.96
Current.....	4.00	63.24

*1 peso per picul—0.3580 cents U. S. currency per pound avoirdupois.

In the New York market the price quoted for Iloilo "Assorted" is practically constant at 1 cent gold per pound less than that of 96° centrifugal. Therefore it would be logical to presume that at least the same difference in value would hold good in Iloilo, or, since a central factory of any size would be in a position to ship its sugar directly to New York at the same cost as if shipped from Iloilo,

the value of 96° centrifugal sugar at the factory in Negros may safely be assumed to be, under normal market conditions, 1 cent gold per pound, or 2.789 pesos per picul, or 44.09 pesos per metric ton greater than that of "Assorted" at Iloilo at any given time. With Iloilo prices as quoted above, 96° centrifugal would be worth at the factory in Negros 9.914 pesos per picul, or 156.75 pesos per metric ton (3.56 cents gold per avoirdupois pound).³⁹

As a basis of comparison of profits by each system may be used the hacienda of 150 hectares just discussed, which produces annually 6,000 piculs (379.5 metric tons) of sugar of 82° polarization from ten times this weight of cane. (Given the composition of the cane as ground (see p. 122), it is a comparatively simple matter to calculate the approximate yield of 96° crystals obtainable by the average modern sugar factory from the same weight of cane. A fairly good mill, consisting of, say, nine rollers, with a preliminary crusher, will lose in the bagasse the equivalent of about 60 parts first mill juice for every 100 parts of fiber present (this is about the average ratio of over 100 estates in Java, as calculated from data given by Geerligs,⁴⁰) and, since the cane as ground in Negros contains 11.79 per cent fiber, the juice lost would amount to 7.07 per cent of the weight of the cane, and there would, therefore, be extracted 85.57—7.07=78.50 per cent of the weight of the cane as juice. The average mill juice in Negros was found to contain 17.20 per cent sucrose, so there would be extracted 13.50 per cent sucrose on the weight of the cane, or 91.70 per cent of the total sucrose. The quotient of purity of the mixed juice would, with this increased extraction, drop about 2 per cent, or to 85. Substituting this figure in the commonly used formula of "available commercial sugar=per cent sucrose extracted in juice $\times$ (1.4— $\frac{40}{\text{purity of juice}}$)"

we find that 92.9 per cent of the sucrose extracted should be recovered as commercial 96° sugar, making a yield of 12.5 per cent sugar on the weight of the cane. From 60,000 piculs (3,795 metric tons) we should expect to get by fairly good working 7,500 piculs (474.4 metric tons) of 96° crystals, half of which or 3,750 piculs (237.2 metric tons), we are assuming, goes to the planter. His cost of production under the new system would be the same as by the old, less 1.16 pesos per picul (18.34 pesos per metric ton) for manufacture and marketing in Iloilo (see pp. 114 and 123), which would make the figure 2.99 pesos per picul (47.27 pesos per metric ton).

The profits of this plantation under the present and under the new system could be estimated as follows:

Present system.

	Pesos
Received from the sale of—	
6,000 piculs } of 82° sugar, No. 3, at { 7 pesos per picul	42,000
379.5 metric tons } { 110 pesos per metric ton }	
Cost of production of the same, at { 4.15 pesos per picul	24,900
{ 65.61 pesos per metric ton }	
Profit	17,100

³⁹ At the time of writing (March, 1910) all prices are very much higher than at the beginning of the season, so that the season's average will probably be considerably higher than these figures quoted above. This does not affect the calculation materially, as the difference in price between 96° and assorted remains unchanged.

⁴⁰ *Internat. Sugar Journ.* (1909), 11, 324.

Central factory system.

Received from the sale of			
3,750 piculs	} of 96° sugar, at	{ 9.914 pesos per picul	} ----- 37,178
237.2 metric tons		{ 156.75 pesos per metric ton	
Cost of growing—			
60,000 piculs	} of cane, at	{ 2.99 pesos per picul	} ----- 17,940
3,795 metric tons		{ 47.27 pesos per metric ton	
Profit			----- 19,238
Increase of profit by new, over old system			----- 2,138

According to these figures, the planter whose sugar averages “No. 3” in quality could, by selling his cane on the estate for half its value in 96° crystals instead of manufacturing it himself, make an increased profit of about 36 centavos for each picul of sugar which he now produces. Calculated to the metric ton of sugar, this increased gain would amount to 5.64 pesos, or about 56 centavos on each ton of cane now grown.

In the case of an estate producing exclusively No. 1 sugar, the gain by selling this very rich cane instead of manufacturing it would not be so large, although an increased profit would still result.

Assuming that the cane grown by the above hacienda were all of the same quality as that ground in Mill Control No. 1 (p. 116), and that it were manufactured in exactly the same manner, except that No. 1 sugar, as it should have been, were produced, the yield of sugar would be 11.15 per cent, hacienda weight, or, deducting for “shrinkage,” 10.87 per cent, Iloilo weight, expressed in per cent on the weight of the cane. To make 6,000 piculs (379.5 metric tons) of sugar would require 55,188 piculs (3,490.6 metric tons) of cane. From the composition of this cane (see p. 116) we find that a fairly good modern mill, by the same calculation as that made previously, would lose in the bagasse 8.78 parts juice and 1.85 per cent sucrose on the cane, and would extract in the juice 15.2 per cent sucrose on the weight of the cane. The purity of the juice would drop about 2 per cent again, or to 89, and the factor $1.4 - \frac{40}{\text{purity}}$ would in this case be 95.1 and there should be yielded, in the form of 96° sugar, 14.45 per cent of the weight of the cane, so that 7,974 piculs (504.4 metric tons) would be produced from the above weight of cane.

The profits under each system would then be:

Present system.

Received from the sale of—		Pesos.	
6,000 piculs	) of sugar, No. 1, at { 7.50 pesos per picul	} ----- 45,000	
379.5 metric tons			{ 118.59 pesos per metric ton
Cost of production, ⁴¹ as in the previous account.....			24,900
Profit			20,000

⁴¹ For lack of more exact information on this point, the cost of production of all grades of sugar is taken to be the same. Although somewhat less cane is required to produce a superior than an inferior sugar, the poorer cane generally grows larger and yields a heavier tonnage per hectare, so that the cost of growing cane equivalent to a given weight of sugar is much the same, whatever the quality.

Central factory system.

Received from the sale of—

3,987 piculs	} of 96° sugar, at {	9.914 pesos per picul	} -----	30,527
252.2 metric tons		156.75 pesos per metric ton		
Cost of growing cane, as before -----				17,940
Profit -----				21,587
Increase profit due to factory system -----				1,487

By changing to the modern system, the estate making nothing but No. 1 sugar would still gain 0.25 pesos per picul (3.93 pesos per metric ton) of sugar or 43 centavos per metric ton of cane now produced.

One of the greatest disadvantages of the system of sugar making still used in Negros is its entire dependence upon the quality of the cane ground for producing a fairly good sugar. There is scarcely a plantation on the island which does not, during the course of the year, turn out a certain amount of low-grade sugar at practically no profit; especially is this the case with those located on new and very rich lands, where the cane grows luxuriantly, but is of rather poorer quality. A large factory, equipped with vacuum pans and centrifugals, is of course able to produce an unvaryingly good quality of sugar from almost any kind of cane, inferiority in the latter simply resulting in a diminished yield.

To illustrate this difference specifically, we can assume that the estate just discussed, through some misfortune, manufactures its entire output of 6,000 piculs as the lowest grade of current sugar. Of course, this would not occur in practice, or the estate would soon go into bankruptcy, but the relative difference in profit from this class of cane will be the same, whatever the percentage of it produced. In Mill Control No. 2 (p. 118) 1 ton of current sugar was produced from 10.61 tons of cane, or, if the sugar is weighed at Iloilo, from 10.89 tons of cane; therefore to produce 6,000 piculs (379.5 metric tons) of concrete sugar from this kind of cane, 65,340 piculs (4,131.7 metric tons) of cane are required. A fairly good modern mill working this cane would lose in bagasse 6.31 per cent juice and 0.87 per cent sucrose, and hence would extract in juice $11.66 - 0.87 = 10.79$ per cent sucrose on the weight of the cane. The purity of the juice could be expected to fall to 75.9, making the empirical factor of availability $1.4 - \frac{40}{\text{purity}} = 87.3$, and as the available 96° sugar in this cane might be considered as 9.42 per cent; 6,154 piculs (389.2 metric tons) of 96° sugar could be made from it.

The profit and loss accounts would be as follows:

Present system.

Received from the sale of—		Pesos.	
6,000 piculs	} of “current” sugar, at {	{ 4 pesos per picul 63.24 pesos per metric ton }	24,000
379.5 metric tons			
Cost of production, as in previous account -----			24,900
Loss -----			900

Central factory system.

Received from the sale of—

3,077 piculs	) of 96° sugar, at {	9.914 pesos per picul	) ---	30,505
194.6 metric tons)		156.75 pesos per metric ton)		
Cost of growing the cane, as before -----				17,940
Profit -----				12,565
Increased profit due to factory system -----				13,465

From this it is evident that from every ton of inferior cane which is now made into "current" sugar at a loss of 22 centavos a metric ton of cane, 2.37 pesos a ton of sugar, or 15 centavos a picul of sugar, there could, by the central factory system, be realized a *profit* to the planter of 3.04 pesos per ton of cane, 33.10 pesos per ton of sugar (figured on the yield now secured), or 2.09 pesos per picul of sugar.

ADVANTAGES OF A CHANGE TO MODERN METHODS OF MANUFACTURE.

It has been shown by the preceding figures that the average planter of Negros should be able to secure considerably more profit from his cane if he could sell it on the plantation for half its value in 96° sugar instead of grinding it himself as at present, the difference in profit being much more marked in the case of a poor quality of cane than with a richer one. In all these calculations, the cost of producing cane has been taken as the total cost of production of sugar by the present method minus the present cost of manufacture and sale of the raw sugar, thus including interest and depreciation on the manufacturing plant now in use. This extra charge against growing the cane, while proper at the present time, since the small mills are already in existence and represent capital invested, would under the central factory system become less each year, since there would be no necessity for the upkeep of individual milling plants, and would be eventually written off, so that the difference in gain, as in the case of a new plantation equipped solely for producing cane, would then be much greater. However, the farmer should not at the start expect too large an actual money profit from a change to the central factory system, for the reason previously stated that, although an increased yield, both in quantity and quality of sugar, would result therefrom, yet the same amount of cane would be forced to pay dividends on much more capital than is now invested. By far the greatest benefit to the farmer which would result from this system would be its freeing him from the cares and troubles of manufacturing his own sugar, thus allowing him to devote all his energy toward the proper cultivation of his fields. This factor is so important that it alone would warrant a change to modern methods; and, even if the profit from a given weight of cane were somewhat less, the greater amount of land which could be put under intelligent cultivation would more than pay for the change. Contrary to the ideas of some, the labor question would be rather improved than

otherwise by such a change. As it is now, ten individual mills of a capacity of 50 tons of cane each require in all from 500 to 700 laborers in the mill house and for sun drying the bagasse, while a modern sugar factory of a capacity of 500 tons of cane per day could do with at least a fifth this number of unskilled laborers, thus leaving a still larger number available for field work. The present low cost of labor in Negros can not be expected to continue indefinitely; the laboring classes of the natives are gradually becoming educated to a higher standard of living, and with this must necessarily follow a higher wage rate, so that the advantages of centralization and mechanical economy of labor must, with time, become more and more apparent.

THE FUTURE OF NEGROS.

Predictions and calculations as to the possibilities of sugar-producing countries are notoriously inexact. In the case of Negros much depends upon the first attempt at the introduction of outside capital and modern methods of milling. A successfully operated central factory in any one of the seven different districts, even if run on a comparatively small scale, would demonstrate its own advantages to the planter more practically than could any amount of papers such as the present one, while if, through mismanagement or lack of tact in dealing with the cane growers, the first factory installed should result unsatisfactorily, the progress of the country would probably be set back many years. Under the present system of production, even with sugar at a high price and more capital at the disposal of the planter, the total annual production of the island can hardly hope to more than treble itself in the next fifteen years, this on the assumption that two-thirds, instead of as at present one-third of all the known available sugar land were to be cultivated, and that the average yield of sugar per hectare could be raised 50 per cent, or to about 4 metric tons, thus yielding in all some 220,000 metric tons of sugar. The advent of more rational methods of sugar manufacture would not in itself, as has been previously shown in detail, cause a greatly increased yield of sugar from the same weight of cane, but its stimulating effect on the industry in general would certainly be very great. It may be estimated conservatively that an extent of land equal to the total of that now known as good sugar soil, or something over 80,000 hectares, could, given the necessary incentive in the way of an increased value and a ready sale for the cane grown, be cultivated in sugar cane annually; while it is, of course, true that not all the land now reported as fit for sugar culture is, or ever can be, cultivated each year successively without giving it a rest during a part of the time by allowing it to lie fallow, or by growing temporarily some other crop, yet there is still considerable virgin forest land as yet undeveloped—in the extreme

southern portion of Occidental Negros, for instance—while, as has been brought out in dealing with the individual districts in a previous part of this paper, a good deal of low land now considered fit only for rice culture could be made available for sugar cane by expending a little money on drainage. It is, moreover, not unreasonable to suppose that the average yield of sugar per hectare, once cane growing were freed from its dependence upon the caprices of manufacture on a small scale and the planter left free to attend to this branch of the industry alone, could, at only a moderately increased expense for fertilizers and irrigation where needed, be raised from the present low figure of 2.71 metric tons (42.9 piculs) to more than double this amount, or, say, 6 metric tons (95 piculs) of sugar per hectare. The possible yield of sugar from Negros under the most favorable conditions would thus be nearly seven times the present one. The probable limits of annual sugar production in Negros during the next fifteen years might, therefore, be estimated at a venture to be about 220,000 metric tons under the present system of small individual mills and estates, and 500,000 metric tons with adequate capital, careful cultivation, and a complete change to modern methods of manufacture. Just which of these limits will be more nearly approached can not be foretold, since it depends almost entirely upon the extent to which new methods shall be substituted for old.

SUMMARY.

A brief description of the Island of Negros is given, together with general information regarding its geographical location, size, shape and area, mountains, rivers, meteorologic conditions, history of its sugar production, varieties of cane grown, nationality of the planters, and the labor available.

Statistics compiled by the Bureau of Internal Revenue for the year 1908 show that at that time there were in the entire island 184 sugar planters, who controlled a total of 65,641 hectares of land, of which 27,096 were under cultivation and 38,545 unplanted. In addition, 16,904 hectares were certified to as being suitable for cane growing, but not at that time so used, making a total of 82,545 hectares of available sugar land in Negros. In that year 73,494 metric tons of raw sugar were produced, or an average of 2.71 metric tons per hectare of land planted. The low average is caused largely by lack of capital and by inefficient cultivation on the part of many of the small growers. The average yield on a well-cared-for plantation should amount to about 4 metric tons per hectare.

Very little damage has ever been reported as having been caused by cane diseases or insects. These subjects are now being taken up as a special investigation by the Bureau of Science.

The Island of Negros may be divided into seven important sugar dis-

tricts, each producing 5,000 tons or more annually, four of these, Silay (comprising the municipalities of Victorias, Saravia, Silay, and Talisay), Bago, Pontevedra-La Carlota, Binalbagan-Isabela and Ilog-Cabancalan, being on the west, and two, San Carlos and Bais, on the east coast. Each of these districts is described separately, representative analyses of soils and sugar cane grown thereon being also given. Silay was found to lead in point of total annual production, although the quality of its soil and the yield per hectare are decidedly inferior to most other parts of the island. The largest production per hectare was found in Ilog-Cabancalan, which averaged 4.45 metric tons, Pontevedra-La Carlota being second with 4.39 metric tons.

The average composition of the soils from all the districts examined is:

Surface soil: Fine earth, 97.39 per cent; potash, 0.20 per cent; soda, 0.18 per cent; lime, 1.66 per cent; magnesia, 0.98 per cent; phosphoric acid, 0.15 per cent; nitrogen, 0.14 per cent; "volatile matter," 9.31 per cent.

Subsoil: Fine earth, 96.10 per cent; potash, 0.17 per cent; soda, 0.17 per cent; lime, 1.79 per cent; magnesia, 0.99 per cent; phosphoric acid, 0.12 per cent; nitrogen, 0.10 per cent; volatile matter, 9.19 per cent.

The Negros soil as a whole may be considered as being decidedly high in lime, but only moderately so in the other constituents of plant food. Compared with sugar soils from other countries, those of Negros, while not exceptionally rich, are fully up to the average, and under proper cultivation should produce as much sugar as those of almost any other country having the same climatic conditions.

Very little attention is paid in Negros to fertilization of any kind. In the case of commercial fertilizers this is perhaps justified by their high price and lack of instruction as to their proper application, but much improvement in crop yields could be brought about at comparatively little expense by a more common utilization of the materials available on every estate, such as bagasse ash, sugar-house refuse, animal manure, and green manuring by planting occasional leguminous crops.

The average composition of clean, ripe cane of the purple or native variety commonly grown in Negros was found in four of the most important districts to be as follows: In the whole cane—average weight 0.92 kilo, sucrose 16.06 per cent, fiber 10.02 per cent; in the juice—Brix 20.35, sucrose 18.40, purity 90.38, reducing sugar 0.71. In comparison with canes from other countries, that of Negros is distinguished by its extreme sweetness and purity and relatively small amount of fiber, factors tending toward an easy and thorough extraction by milling. The percentage of fiber in this cane is in actual practice about 2 per cent higher because of trash ground with the cane.

Although a marked improvement on the native cane in respect to

sucrose content and free-milling qualities is hardly to be expected, it is recommended that a few other good varieties of cane be introduced into Negros and grown somewhat extensively, so as to have a reserve to fall back on for seed in case the present variety should ever be attacked by disease of any kind. Experience in other countries has proved that it is a dangerous policy to rely entirely upon one variety of cane. Some black cane is now being grown in Negros, and this, because of its rather high fiber content and habit of growing erect, should prove desirable as a substitute for the purple cane in certain very rich or sandy soils, where the latter has a tendency to fall down badly and not mature.

Cultural operations are much the same in Negros as in other countries. After burning a field and plowing it, the seed is laid out in rows, about 25,000 being planted to the hectare. Only the cane tops are used for planting. Planting is carried on at the same time as cutting and grinding, usually between the months of November and May, and the cane remains in the ground to ripen for from ten to fourteen months. The carabao is the only work animal at present used. Ratoon canes are extensively grown in Binalbagan-Isabela, Ilog-Cabanacan, San Carlos, and Bais; in the majority of other parts of the island they are the exception rather than the rule. Approximately one-half of each year's crop throughout the island may be said to come from plant cane. Cane is cut and loaded by hand, and carried to the mill in bull carts or by means of light, portable tramways.

The mills of Negros are of the single, three-roller type, nearly all run by steam, and having an average capacity of about 50 to 60 metric tons of cane per day of twelve to fourteen hours. Bagasse is used for fuel, but is not crushed dry enough to be burned directly, so it must be given a preliminary drying in the sun, which entails considerable extra expense and renders the planter dependent on fair weather for running his mill.

From tests made from a large number of mills in different parts of Negros, it is calculated that from 20 to 35 per cent of the total sucrose of the cane is lost in the bagasse, depending upon the amount of fiber in the cane. The average loss is 25 per cent, giving a juice extraction of 64.5 per cent on the weight of the cane, a figure somewhat better than might be expected, due not to any superior efficiency of the mills, but rather to the small amount of fiber in the cane usually ground.

The juice is boiled down in a train of open, hemispherical, iron kettles set over a direct fire. It is defecated with lime, and a fairly good clarification is effected in the first four of these kettles by skimming impurities off from the surface. The sirup, after clarification and concentration to about 50° Brix is boiled down in the final kettle to a

"massecuite" of from 5 to 10 per cent water content, then poured out into shallow trays and stirred with a spade until it crystallizes. No attempt is made to separate sugar and molasses, but the whole "concrete" is sacked and sold as such.

The losses of sucrose in open-kettle boiling occur chiefly in the final boiling of "massecuite," where a large amount of sugar may be caramelized and even burned by local overheating and sticking to the sides of the kettle. Where filter presses are not used, a great deal of sugar is also thrown away in the skimmings. Very little loss by inversion occurs in the preliminary clarification and concentration to 50° Brix in the first four kettles, provided only moderate care is taken in liming to approximate neutrality.

Heretofore it has been impossible to secure reliable data as to the amount of sugar produced in Negros from a given weight of cane, since the cane itself is never weighed, and the sugar, as a rule, only after it reaches Iloilo and is sold. After considerable difficulty it was found possible to make two complete mill controls of cane of widely different composition, and from a combination of the data thus obtained and comparative analyses of juices and sugars from a large number of mills throughout the island the average in sucrose ordinarily produced is calculated to be approximately the following:

Loss—	Sucrose in cane.
	<i>Per cent.</i>
In bagasse.....	25.0
In skimmings.....	5.0
By inversion.....	2.5
Burned, spilled, stolen, and unaccounted for.....	10.0
"Shrinkage" en route to Iloilo before weighing.....	1.5
Total.....	44.0

The cane as ordinarily ground in the mills averages 14.72 per cent sucrose, so the yield in sucrose on the weight of the cane amounts to 8.24 per cent, or almost exactly 10 per cent of raw sugar polarizing 82°, the average polarization of Negros sugar.

Negros sugar is practically all sold in Iloilo, where it is classified as "Superior" Nos. 1, 2, and 3. "Wet," and "Current," of polarization minima of 87°, 85°, 80°, 76°, and 70°, respectively. The difference in market price has heretofore been arbitrarily fixed at 25 centavos between grades of "Superior." The two lower grades have usually been shipped to China, and bear no fixed price relation to the "Superior" sugars.

The average cost of producing sugar by the present process in Negros is estimated as approximately the following:

	Cost per picul of sugar.	Cost per metric ton of sugar.
Plowing, planting, and caring for the cane until it is ready to cut	<i>Pesos.</i> 0.60	<i>Pesos.</i> 9.49
Cutting the cane	.16	2.53
Carting cane to the mill	.16	2.53
Grinding the cane and manufacture of sugar	.63	9.96
Shipping to Iloilo and marketing there	.53	8.38
Total fixed expenses, including 10 per cent deprecia- tion and 10 per cent interest on the capital invested ..	2.07	32.72
Total	4.15	65.61

A few possibilities for improvement are suggested, the chief among them being the substitution of modern methods of manufacture. It is shown that the average planter could by selling his cane to a central factory earn a somewhat larger profit from it than by manufacturing it into sugar himself under the present method, the difference in profit being much more marked with inferior than with very rich and pure cane. The greatest benefit to the planter under the modern system would result from his being thereby rendered independent of manufacturing details and largely of weather conditions, so that he would be enabled to operate on a much smaller working capital and at the same time secure better results from his land.

The annual limits of sugar production in Negros during the next fifteen years may be estimated at about 220,000 metric tons of low-grade sugar under the present system of manufacture or 500,000 metric tons of 96° centrifugal sugar if a complete change should be made to modern methods of manufacture. The larger production under the modern system would be due not so much to a greatly increased yield as to the stimulus to the industry in general and consequent improvement in cultural methods which would follow in its train.

APPENDIX.

AN INVESTIGATION TO DISCOVER IF DISEASES OF THE SUGAR CANE EXIST IN NEGROS.

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FUNGUS AND OTHER DISEASES.

Philippine sugar cane appears, after a preliminary investigation, to be rather remarkably free from disease. There are unquestionably certain fungi, parasitic on the sugar cane, present in the Philippines, but it appears to be rare that any of these become sufficiently abundant to injure the cane in any noticeable degree.

The only serious disease that has come to our notice was an outbreak of the sugar cane smut, caused by the fungus *Ustilago sacchari*, in Laguna Province, Luzon, in the year 1908. This outbreak was investigated by Dr. C. B. Robinson, of this Bureau, and although the fungus was found to be abundant in certain fields, and quite fatal to the young plants, it was very local in extent and quickly disappeared under proper cultural treatment. Doctor Robinson's report on this case will be found in the Philippine Agricultural Review.¹

In the early part of the present year a verbal report was received at the Bureau of Science to the effect that the sugar cane throughout Negros, and, in fact, in other parts of the Philippines, was badly infected with "red rot," caused by the fungus *Colletotrichum falcatum*. It was stated that this disease was so common in the Archipelago that it would be unwise to use Philippine sugar cane for seed in establishing new plantations on account of the danger of infection. "Red rot," although not exceedingly difficult to control, has, in some countries, caused much damage to the cane fields, so that, considering the nature of the report and the reputed seriousness of the attack, it was deemed expedient to investigate at once. In May, 1910, the sugar-cane districts about Cabancalan, Negros, and Bago, Negros, were visited, but a careful search in a number of different fields failed to reveal a single specimen of sugar cane infected with the fungus, nor were any of the canes examined found to suffer from other diseases that might be mistaken for the above malady. No traces of "red rot" have been found on sugar cane in the vicinity of Manila, and Dr. E. B. Copeland, dean of the College of Agriculture at Los Baños, informs us that he has been unable so far to find it in Laguna Province.

While searching for the "red rot" of the sugar cane in Negros, advantage was taken of the opportunity to collect specimens of all other fungi parasitic on the

¹ *Phil. Agric. Rev.* (1908), 1, 295-297.

cane. Two or three different species were found, including probably *Cercospora sacchari*, causing the so-called "eye spot disease" of the sugar-cane leaf, which is of very minor importance. The remaining species are at present unidentified, but it is confidently assumed that none of them are of a decidedly injurious nature. Parasitic fungi are very rare in Negros—it was only occasionally that a plant could be found that was infected by any fungus—and in no case was a plant found to be badly infected.

"Root rot," caused by various fleshy fungi, "red-rot," as noted above, "rind disease," "top rot," or any other fungous or bacterial disease of a serious nature was not observed by us in Negros. The matter was discussed with several planters, and none of them could recall ever having seen any of the maladies in question. The latter statement is, of course, of rather doubtful value in determining whether or not various diseases are or have been present, as an untrained person might easily overlook them, or fail to credit minor injuries to his sugar cane to the proper causes. While it is not claimed that some or all of the diseases mentioned above are not present in the Philippines, it is maintained that if they are present, they are of such rare occurrence, that the damage being done by them in the Philippines at the present time is a negligible quantity.

INSECTS.

As some attention had been given to the question of sugar-cane insects in Negros about eight years ago, and as at that time few serious pests were encountered, it was surmised that the reports this year might be exaggerated and that there was no greater abundance of insects than usual.

A careful investigation was made, therefore, over a territory of some 10 square kilometers in the region of Cabancalan on the Ilog River and about 2 square kilometers at Bago farther north. Inquiries among the farmers brought out the fact that for forty or more years sugar has been raised annually upon the same plots of ground without recourse to fertilizers or rotation of crops, or even a change of seed plants more than from one hacienda to another in the same locality.

Naturally any insects that might have a special predilection for sugar cane would go on increasing slowly from year to year under a condition of practically absolute immunity, excepting the possible attacks of natural parasites.

The attacks of insects upon sugar cane, at the present time, can not be said to be serious, except that in so far as they remain unchecked they go on increasing, and it is probably only a matter of a certain number of years when it will be impossible to raise sugar cane on those lands where farmers, instead of trying to plow and cultivate as many times as possible in a season, seem to wish to do this as few times as they can and never pay attention to rotation of crops or resting the land.

THE CANE ROOT BEETLE.

(*Holotrichia vidua* Sharp) [*McIlonthidæ*.]

This beetle is probably the most serious pest in the sugar-cane region visited. The larvæ, pupæ, and full-grown beetles were found in numbers in the ground around the roots of first and second year *calaanan*,² or ratoons. From a single

² Calaanan is a Visayan term used to designate cane which springs up after the crop has been cut off a field. In the region visited as many as eight crops have been harvested without a replanting of cane seed, or "*puntas*," as they are called locally.

hill in a field from which the cane had been cut two months previously, fourteen adults, three pupæ, and seven larvæ were taken.

Little or nothing is known of the length of larval life of this particular species, but, based upon a knowledge of related insects, the assertion can safely be made that deep and repeated plowing and other vigorous cultural methods accompanied by allowing the land to rest for one or two years and the planting of other crops would be the only means of successfully combating this insect.

THE CANE TIP BORER.

(? *Scirpophaga intacta* Sn.) [*Pyralidæ*.]

The young cane, three to four months old, over certain large areas was badly attacked by a tip borer resembling, in the appearance of the larva and the character of its work, the species described by Van Derventer³ as damaging sugar cane in Java.

It is claimed by the farmers in Negros that this insect, rather than being injurious, serves as a pruning agent, thereby reducing the excessive number of ratoons springing from a single hill, and thus saving them the labor of cutting out the excess of plants.

It would seem that this is a very poor means of accomplishing such a result, especially as cases have been seen where all the plants in many rows 8 to 10 meters long were affected. Moreover, the energy expended by the plant in sending up these excessive ratoons, later to be destroyed by insects, might have been utilized in the production of fewer and more robust ratoons, less subject to insect attacks.

As there was no time to investigate the whole life history of this insect when I visited these plantations, it is impossible to state the best season for cutting and destroying plants known to be attacked. It is very easy to distinguish them in a given field, as their top and center leaves are invariably dead and of a pale yellow hue.

THE WHITE LEAF LOUSE.

(*Oregma lanigera* Zehnt.) [*Aphidæ*.]

This insect was found in great abundance on a single hacienda near the town of Cabancalan, one field of about four months' old cane being very badly infested. There is no doubt but that the serious degree of infestation was due to the excessive crowding of the plants and the absolute lack of any cultivation since the old crop had been cut off.

It was very evident that the only remedy for this condition of things was to burn off the infested cane and either replant after proper preparation of the ground or trust to a resprouting from the old stands. Both of these methods were suggested to the owner, but he seemed quite unwilling to take the responsibility, as the cane was being worked on shares with another man.

The size of the field and the dense growth of the cane would have precluded any attempt at spraying such as is recommended by Van Deventer,⁴ even if the farmers in this part of the world were familiar with the use of sprays and spraying apparatus.

³ Handboek ten dienste van de Suikerriet-Cultuur en de Rietsuiker-fabricage of Java. Tweede Deel, de Dierlijke Vijanden van het Suikerriet (1906), 114.

⁴ *Loc. cit.* 187 and 196.

THE CANE FULGORID.

(*Phenice moesta* Westw.) [*Fulgoridæ*.]

While no other insects were found attacking cane in Negros, there is another which may prove of interest should it increase in parts of Luzon where it has been observed.

This small, black and white insect has been met with frequently in Manila and vicinity, resting in large numbers on the undersides of cane leaves and sucking their juices.

It has been reported as damaging certain palms in Assam and as attacking leaves of sycamore in Java, but I believe no mention has hitherto been made of danger to sugar cane from its attack.

While these investigations of sugar insects showed a condition of rather general and widespread infestation, they indicate a serious present menace in but one or two places. However, they mean that the farmer can not longer depend upon unassisted nature in his cultivation of cane.

INDEX.

- Analyses of bagasse ash, 74
 Analyses, cane, district of Bago, 34, 35; district of Ilog-Cabancalan, 54; district of Pontevedra-La Carlota, 42; district of San Carlos, 63.
 Analyses, mechanical, of Negros soils, 69.
 Analyses, soil, district of Bago, 30-33; district of Bais, 66-67; district of Binalbagan-Isabela, 45-47; district of Ilog-Cabancalan, 57; district of Pontevedra-La Carlota, 39-41; district of San Carlos, 58-61; district of Silay, 22.
 APHIDAE, 141.
 Approximate cost, of plowing, planting and caring for 1 hectare of land, 88.
 Approximate daily cost of operating sugar mill in Negros, 113.
 Area and production of district of Bago, 29; of district of Bais, 65; of district of Binalbagan-Isabela, 44; of district of Pontevedra-La Carlota, 38; of district of San Carlos, 57; of district of Silay, 22.
 Artificial fertilizers, 74.
 Ash, analyses of bagasse, 74.
 Average composition of Negros cane, 76; of purple cane, 76.
 Average temperature at Bacolod, 14; at La Carlota, 13.
 Bacolod, average rainfall at, 13; average temperature at, 14; maximum and minimum rainfall at, 13; maximum and minimum temperature at, 14.
 Bagasse ash, analyses of, 74.
 Bagasse, mill juice per 100 fiber in, 97, 98.
 Bais, analyses of soils of, 66, 67; area and production of, 65; haciendas of, 61; harbor of, 64; location of, 15, 64.
 Bago, analyses of cane from, 34, 35; analyses of soils of, 30-33; area and production of, 29; composition of soils of, 28; location of, 27; sugar soils of, 28; total yield of sugar in district of, 29.
 Bago River, 28.
 "Bankil" soils, 50.
 Beetle, cane root, 140.
 Berbice soils, 72.
 Binalbagan-Isabela, analyses of soils of, 45-47; area and production of, 44; topography of, 43.
 "Bembon," 49.
 Boiling, of sugar, 102; losses during, 103.
 Bolo, used in cutting the cane, 91.
 Borer, cane tip, 141.
 "Bucan," 19.
 "Bugan," 19.
 Bullocks, used in transporting cane to mill, 91.
 Bureau of Internal Revenue, 9.
 Burning of cane, 82.
 Caña morada, 18.
 Cane, analyses of from Bago, 34, 35; from Ilog-Cabancalan, 54; from Pontevedra-La Carlota, 42, 43; from San Carlos, 63; transporting to mill, 91; methods of transporting, 91; burning of, in preparation of soil, 82; cost of cutting and transporting to mill, 92; cultivation of, after planting, 84, 85; cultivation of ratoon, 85; determination of weight of, 114, 115; diseases of, 19; Egyptian, 80; growth of, 86; Hawaiian Island, 79; insect enemies of, 19; irrigation as a source of increasing yield of, 126; Java, 80; Louisiana, 80; Louisiana purple, 19; low content of bagasse ash in, 74; manufacture of sugar from, 92; Negros, 76; other varieties grown in Negros, 77; present production of sugar, in Negros, 82; sugar content of, 81; varieties of, grown in Negros, 18; West Indian, 81.
 Cane fulgorid, 142.
 Cane root beetle, 140.
 Cane tip borer, 141.
 Caingins of San Carlos, 57.
 Capital, lack of in Negros, 134.
 Carabaos, number necessary for 1 hectare of land, 83.
 Central factory, advantages of, 133; central sugar, 127, 130; profits from, 130.
 Chinese bullocks, used in transporting cane, 91.
 Clarification of juice, 101.
 Climate, 11.
 Composition of Negros soil, average, 68-69.
 Content of sugar in cane, 81.
 Cost, approximate, of plowing, planting and caring for 1 hectare of land, 88, 89; average, of production by present methods, 123; of manufacture of sugar, 112; of shipping sugar to Iloilo, 114; summary of cost of production in Negros, 123.
 Cutting the cane, 90.
 Danao River, 11.
 Demerara soils, 71.

- Disease, little damage reported by, 134.
Drought in San Carlos, 57.
East coast of Negros, 15.
Egyptian cane, 80.
Egyptian soils, 70.
Experiments, quantitative, 114.
Factories, central sugar, 127.
Fertilization, in Negros, 73; necessity of, 73.
Filter-press mud, 104.
Fortuna, hacienda, 56.
FULGORIDAE, 42.
Future of Negros, 133.
General information regarding Negros, 10.
Hacienda Carmencita, district of Pontevedra-La Carlota, sugar boiling test, 105.
Hacienda Fortuna, 56.
Hacienda Lumañub, district of Bago, sugar boiling test, 106.
Hacienda San José, mill equipment on, 115.
Hacienda Santo Tomas, 56.
Hacienda Valle Hermoso, 56.
Harbor of Bais, 64.
Hawaii, leads in sugar production, 72.
Hawaiian soils, 70.
Hawaiian Islands, 79.
ILOLOTRICHIA VIDUA Sharp, 140.
Ilog River, 15, 49.
Ilog-Cabancalan, analyses of cane from, 54; analyses of soils of, 51-53; area and production of, 50; composition of cane of, 55; formation of sugar lands of, 49; location of, 49.
Iloilo markets, price of sugar in, 128.
Insects, little damage reported by, 134.
Improvements, possibility for, in cultivation of sugar, 126.
Impurities, maximum percentage, 102.
Impure sirup, 108.
Irrigation, as a source of increasing yield of cane, 126.
Iron cars, used in transporting cane to mill, 91.
Java cane, 80.
Java soils, 71.
Jimamaylan, 49.
Juice, extraction of, from cane, 92; clarification of, 101; local name for, 102; manufacture of sugar from, 99.
Kalaanang, 86.
Laborers, where secured, 20; wages paid, 20.
Lime, in Negros soils, 48; slaked, as fertilizer, 74.
Liming, 101.
Local names for juice, sirup and sugar, 103.
Losses during boiling, 103; inversion, 104; mechanical, 108.
Louse, white leaf, 141.
Louisiana cane, 80.
Louisiana soils, 71.
Manufacture, advantages of modern methods of, 132; modernizing methods of, 127.
Market, Iloilo, for Negros sugar, 128; New York, for Negros sugar, 128.
Mauritius soils, 72.
Mechanical analyses of Negros soils, 69.
Mechanical losses, 108.
MELOLONTIIDAE, 110.
Milling plant, type of, 96.
Mills, efficiency of sugar, 94; three classes of sugar, in Negros, 92.
Modern methods, advantage of, in manufacture of sugar, 132.
Mount Canloan, 11.
Mountain chain, principal, 15.
Mountains, 11.
Mud, filter-press, 104.
Municipality, table showing land cultivated in sugar in each, 17.
Native labor, difficulties past and present, 20; difficulty with, 20, 21.
Negros, cane of, 76; cause of low average yield in, per hectare, of land, 134; future of, 133; geographical location of, 10; handicapped by severe tropical rains, 73; nationality of planters in, 19; number of planters in, 134; seven important sugar districts of, 135; size, shape and area of, 10; soils of, compared with other countries, 72.
New York market, price of Iloilo sugar in, 128.
OREGMA LANIGERA Zehnt., 141.
Other sugar-producing districts of Negros, 15.
Planters of Negros, 134; nationality of, 19.
Planting, different methods of, 83, 84.
Plow, present style of, used in Negros, 83.
Plowing sugar fields, 82.
PHENICE MOESTA Westw., 142.
Pontevedra-La Carlota, analyses of cane from, 42; analyses of soils of, 39-41; average composition of soils of, 41; abandoned land of, 37; area and production of, 38; topography of, 37.
Preparation of sugar soil, 82.
Price of sugar in Iloilo markets, 128.
Purple cane, average composition of, 76.
PYRALIDAE, 141.
Quality of sugar, produced in Negros, 109-111.
Quantitative experiments, 114.
Rainfall, at La Carlota, 12, 13; at Bacolod, 13.
Ratoon cane, cultivation of, 85.
Recoletos, 19.
Refugio Island, 55.
Rivers, of Negros, 11.
Sale of sugar, 113.
San Carlos, analyses of cane, 63; analyses of soils of, 54-61; area and production of, 57; location of, 15, 55; location of sugar plantations of, 56.
San Enrique River, 37.
Santo Tomas, 56.

- SCIRPOPHAGA INTACTA Sn., 141.
- Scums, 104.
- Seed, white cane tops used for, 83; number of, per hectare, 83.
- Sirup, impure, 68; local name for, 103.
- Silay, analyses of soils of, 23, 24; area and production of, 22; quality of sugar produced in, 27.
- Skimmings, 104.
- Soil analyses, district of Bago, 30-33; district of Bais, 66, 67; district of Binalbagan-Isabela, 45-47; district of Ilog-Cabancalan, 51-53; district of Pontevedra-La Carlota, 39-41; district of San Carlos, 58-61; district of Silay, 22-27.
- Soil, average composition of in Negros, 35; comparison of Bago, with Silay, 33; Negros, compared with other sugar-producing countries, 68.
- Soils, "bankil," 50; Berbice, 72; Demerara, 71; Egyptian, 70; fertilization of Negros, 73; Hawaiian, 70; Java, 71; "Iamákan," 65; Louisiana, 71; Mauritius, 72; of Negros, 48, 72.
- Suay, 49.
- Subsoils of Negros, 68, 69.
- Sucrose, burned in manufacture, 108; percentage of, lost in bagasse, 117.
- Sugar, amount produced, 10; average yield per hectare, 19; average yield of raw, per ton, in Negros; average cost of production by present methods, 123; boiling test for, 105; cost of manufacture, 112; cost of shipping to Iloilo, 114; local name for, 103; manufacture of, from cane, 92; manufacture of, from juice, 99; price of, in Iloilo markets, 128; quality of, produced in Negros, 1909-111; sale of, 113; transportation of, 113.
- Sugar belt, of Negros, 14.
- Sugar center, comprised of seven large districts, 15.
- Sugar content of cane, 81.
- Sugar house, arrangement of, 99, 100.
- Sugar industry of Negros, from statistical point of view, 9.
- Sugar mill, approximate daily cost of operating, 113.
- Sugar plantation, capital necessary for, 123-126.
- Surface soils, of Negros, 68, 69.
- Statistics, recent, 16.
- Steam mills, 92.
- Temperature, at La Carlota, 12, 13; at Bacolod, 13, 14.
- Test, sugar boiling, 105.
- The East Coast of Negros, 15.
- The Sugar belt, of Negros, 14.
- Tierra mestiza, 50.
- Torils, 73.
- Transportation of sugar, 113.
- Transporting the cane to mill, 91.
- Type of milling plant, 96.
- Valle Hermoso, Hacienda, 56.
- Wages, paid laborers, 20.
- Water power sugar mills, 92.
- Weather Bureau, 11.
- White cane tops, used for seed, 83.
- White leaf louse, 141.



FIG. 1. PLOWING A FIELD BEFORE PLANTING.

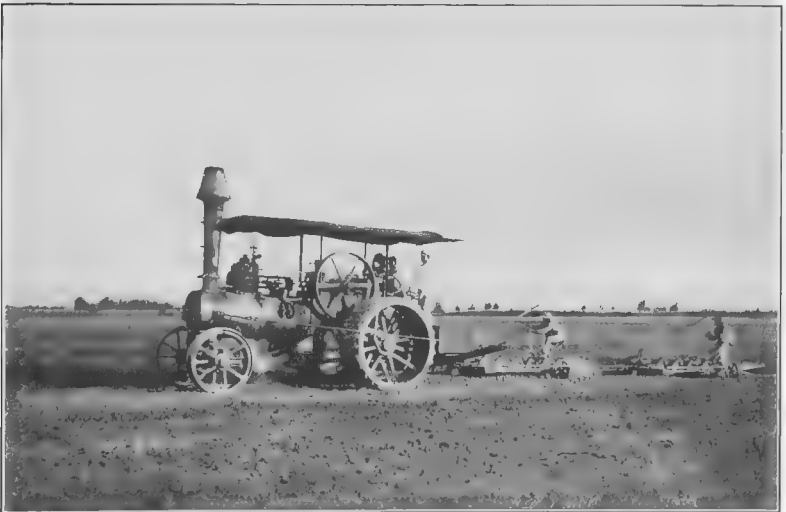


FIG. 2. STEAM PLOWING ENGINE DRAWING TWO DISC PLOWS.

PLATE I.



FIG. 1. PLOWING BETWEEN THE ROWS.



FIG. 2. BOYS CLEARING OUT THE WEEDS.

PLATE II.



FIG. 1. TAKING AWAY THE DIRT FROM AROUND THE ROOTS OF YOUNG RATOONS.



FIG. 2. CUTTING CANE IN THE FIELD.

PLATE III.

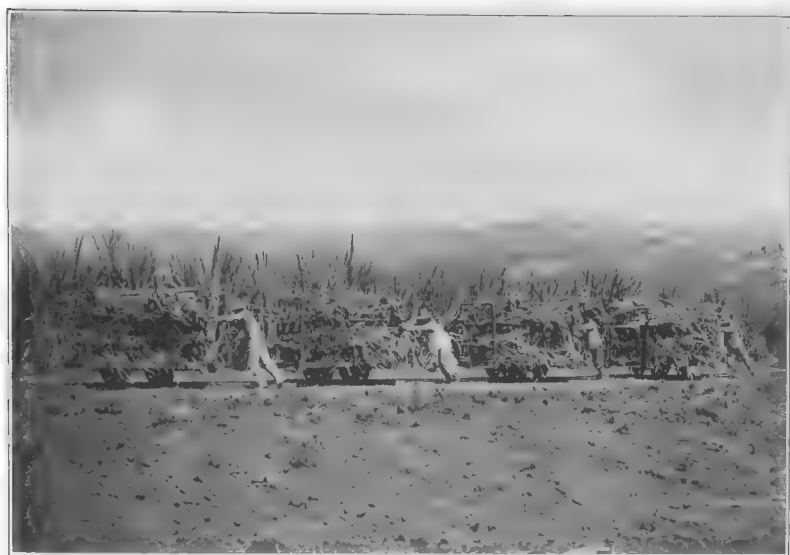


FIG. 1. TRANSPORTING CANE IN A MAN-POWER TRAMWAY.



FIG. 2. CUTTING SEED, OR "PUNTOS," FROM CANE TOPS.

PLATE IV.



FIG. 1. WOMEN AND CHILDREN HUSKING PUNTAS.



FIG. 2. LOADING CANE ON WAGONS.

PLATE V.



FIG. 1. HAULING CANE FROM THE FIELD.



FIG. 2. SUGAR MILL IN ACTION.

PLATE VI.



FIG. 1. CARABAO MILL.



FIG. 2. INTERIOR OF THE CAMARIN.



FIG. 1. CAMARIN AND CARABAO CARTS.



FIG. 2. SIDE VIEW OF CAMARIN.

PLATE VIII.



FIG. 1. SUGAR BOILING IN NEGROS.

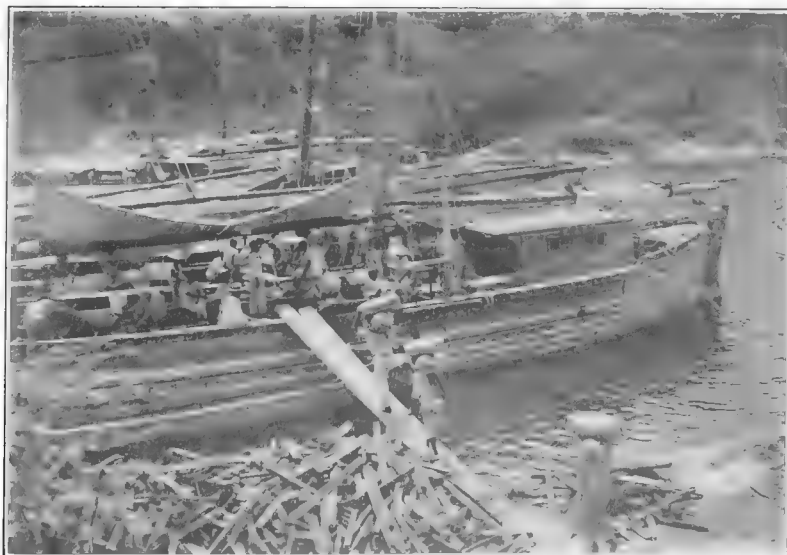


FIG. 2. LOADING SUGAR ON LORCHAS.

PLATE IX.



FIG. 1. THE BAGO RIVER AND SUGAR LORCHAS.



FIG. 2. TEMPORARY EXPERIMENTAL LABORATORY.

PLATE X.

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